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The Influence of Air on Vacuum in Surface Condensers.*

BY D. B. MORISON, ESQ.

A paper was read by Prof. R. L. Weighton before this institution in April, 1906, the essential object of which was to demonstrate the effect of design on the efficiency of surface condensers, with particular reference to a series of tests carried out at Armstrong College, Newcastle. The present paper deals with the effect of air on vacuum in surface condensers.

Saturated Air.—If a condenser contains steam only and no air, the vacuum would be governed by the mean temperature of the steam throughout the condenser, and an air pump would not be required. In practice, air exists in all steam condensers; its presence has the effect of retarding the condensation of the steam on the tube surface, and it has to be removed in a state of saturation with water vapor by an air pump.

When a condenser is at work and a stable condition has been established, the weight of air entering and leaving it in a given time is the same; but the ratio of air to steam in different parts is very variable. At the steam inlet the proportion of air to steam is, in a reasonably air-tight system, so small that the effect is negligible. As the fluid passes through the condenser and the steam condenses, the rate of air to steam increases rapidly until at the air-pump suction the air forms a very considerable proportion of the mixture. It is customary to refer to the fluid entering the condenser as "steam," and to the fluid leaving it as "air," but the two are of precisely the same nature

*Read at Institution of Naval Architects.

TABLE I.

TEMPERATURES AND PRESSURES OF SATURATED STEAM.

Absol. pressure. Lbs. per square inch.	Temperature. Degrees Fahr.	Vacuum. Inches of mercury when bar. is at 30 in.	Absol. pressure. Lbs. per square. inch.	Temperature. Degrees Fahr.	Vacuum. Inches of mercury when bar. is at 30 in.
0·0982	36	29·8	1·277	110·5	27·4
0·1474	46	29·7	1·326	111·5	27·3
0·1965	53·5	29·6	1·375	113	27·2
0·2456	60	29·5	1·424	114	27·1
0·2947	65	29·4	1·474	115	27·0
0·3438	69	29·3	1·523	116·5	26·9
0·3929	73	29·2	1·572	117·5	26·8
0·4421	76	29·1	1·621	118·5	26·7
0·4912	79·5	29·0	1·670	119·5	26·6
0·5403	82·5	28·9	1·719	121	26·5
0·5894	85	28·8	1·768	122	26·4
0·6385	87·5	28·7	1·817	123	26·3
0·6876	90	28·6	1·866	124	26·2
0·7368	92	28·5	1·916	125	26·1
0·7859	94	28·4	1·965	126	26·0
0·8350	96	28·3	2·063	128	25·8
0·8841	98	28·2	2·161	129	25·6
0·9332	99·5	28·1	2·259	131	25·4
0·9823	101·5	28·0	2·358	133	25·2
1·031	103	27·9	2·456	134	25·0
1·081	104·5	27·8	2·554	135·5	24·8
1·130	106	27·7	2·652	137	24·6
1·179	107·5	27·6	2·751	138	24·4
1·228	109	27·5	2·849	139·5	24·2

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TABLE II.

TEMPERATURES AND PRESSURES OF SATURATED AIR.

Vacuum. Inches of mercury with bar. at 30 in.	Proportions of Air and Steam by Weight.				
	No Air, i.e. Sat. Steam.	Air 0·25. Steam 1·0.	Air 0·5. Steam 1·0.	Air 0·75. Steam 1·0.	Air 1·0. Steam 1·0.
Inches.	Degrees F.	Degrees F.	Degrees F.	Degrees F.	Degrees F.
29	79·5	75	71	67·5	64·5
28	101·5	96·5	92·4	88·8	85·3
27	115	110	105·6	101·7	98·6
26	126	120·2	115·5	111·5	108·3
25	134	128·4	123·5	119·2	116·2
24	141	135·2	130·3	125·8	122·3

and differ only in the proportion of the constituents. It is true that what is termed air may not have exactly the same composition of atmospheric air, but this is a point of little consequence in the present investigation.

Table I.—There is, as is well known, a definite temperature corresponding to any pressure of saturated steam. This is given by Table I, a column representing vacuum expressed as inches of mercury being added to the usual columns expressing absolute pressure and temperature. But there is also a definite and lower temperature corresponding to every proportion of air to steam in saturated air at every pressure.

Table II.—This table gives the vacuum and corresponding temperature of airless steam and also of three proportions of air to steam, which are merely chosen to exemplify the principle. It will be seen from these tables and from diagram II that for a given vacuum the fall in temperature of the gaseous mixture which passes through a condenser and on to the air pump changes with the ratio of air to steam in a perfectly definite manner; and this property, which has not hitherto received the recognition it deserves, has an important bearing on all investigations on this subject.

Diagram I.—I have found this diagram of great service in dealing with condenser and air pump problems, and a brief explanation regarding it, and also Table III, which expresses the same results in tabular form. may be of interest. The first column in the table is one of temperatures, and the second column gives the pressure of water vapor corresponding to these temperatures. This relation between the presssure and the temperature of steam has already been given in Table I, and is, of course, well known.

It is important to note that, if water vapor is mixed with another gas or gases, the total pressure is the sum of the presssures of the several constituents, the pressure of each of which may be termed the partial pressure. The partial pressure of the water vapor is dependent only on the temperature; it is unaffected by the presence of the other gas or gases. The third and fourth columns refer to a vacuum of 24 in. of mercury when the barometer is at 30 in., the corresponding absolute pressure being 2.95 lbs. per square inch. If air saturated with water vapor is at a temperature of, say, 50 degrees Fahr., and if its total pressure is 2.95 lbs., then, as the partial pressure of water vapor at this temperature is 0.17 lb., the partial pressure of the air must be the difference between these figures, i. e., 2.95 — 0.17 = 2.78 lbs. per square inch, as given at the top of the third column of the table. The volume of air is, as is well known, dependent upon its temperature and pressure, and can be readily calculated if these data are given. The fourth of the table gives the volume of 1 lb. of saturated air. This has been calculated from the partial pressure of the air; the volume of the water vapor which occupies the space coincidentally with the air does not affect the result. The

DIAGRAM I.

VOLUME OF 1 LB. OF AIR WHICH IS SATURATED WITH WATER VAPOUR AT VARIOUS TEMPERATURES AND VACUA.

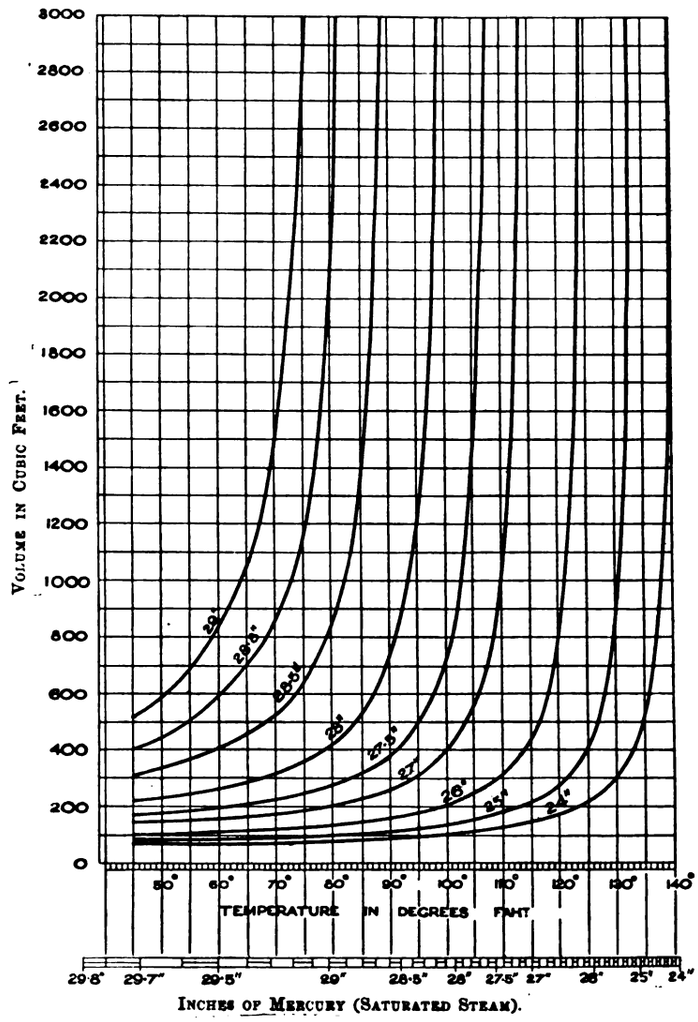

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TABLE III.

VOLUMES OF AIR SATURATED WITH WATER VAPOUR AT VARIOUS TEMPERATURES AND VACUA.

Temp. in Degs. Fahr.	Pressure of Water Vapour at this Temp.	Vacuum 24 in corresponding to 2·947 lbs. per sq. in		Vacuum 26 in. corresponding to 1·965 lbs. per sq. in.		Vacuum 27 in corresponding to 1·474 lbs. per sq. in		Vacuum 27·5 in. corresponding to 1·228 lbs. per sq. in.		Vacuum 28 in. corresponding to 0·9823 lb. per sq. in.		Vacuum 28·5 in. corresponding to 0·7368 lb. per sq. in.		Vacuum 28·8 in. corresponding to 0·5894 lb. per sq. in.		Vacuum 29 in. corresponding to 0·4912 lb. per sq in.	
		Partial Pressure of Air.	Volume of 1 lb. of Air with accompanying Vapour	Partial Pressure of Air	Volume of 1 lb. of Air with accompanying Vapour.	Partial Pressure of Air.	Volume of 1 lb. of Air with accompanying Vapour	Partial Pressure of Air.	Volume of 1 lb. of Air with accompanying Vapour	Partial Pressure of Air.	Volume of 1 lb. of Air with accompanying Vapour.	Partial Pressure of Air.	Volume of 1 lb. of Air with accompanying Vapour	Partial Pressure of Air.	Volume of 1 lb. of Air with accompanying Vapour.	Partial Pressure of Air.	Volume of 1 lb. of Air with accompanying Vapour.
	Lbs. per sq. in.	Lbs. per sq. in.	Cubic ft.	Lbs. per sq. in.	Cubic ft.	Lbs. per sq. in.	Cubic ft.	Lbs. per sq. in.	Cubic ft.	Lbs. per sq. in.	Cubic ft.	Lbs. per sq. in.	Cubic ft	Lbs. per sq. in.	Cubic ft.	Lbs. per sq. in.	Cubic ft.
50°	0·17	2·78	68	1·79	105	1·30	147	1·06	176	0·81	233	0·57	336	0·42	450	0·32	592
60°	0·25	2·70	71	1·71	113	1·22	158	0·98	197	0·73	263	0·49	393	0·34	566	0·24	800
70°	0·36	2·59	75	1·60	124	1·11	178	0·87	266	0·62	315	0·38	520	0·23	852	0·13	1536
80°	0·50	2·45	81	1·46	137	0·97	204	0·73	273	0·48	420	0·24	832	0·09	over 2000	—	—
90°	0·69	2·26	90	1·27	163	0·78	260	0·54	379	0·29	700	0·05	about 4000	—	—	—	—
100°	0·94	2·01	103	1·02	203	0·53	390	0·28	727	0·042	nearly 5000	—	—	—	—	—	—
110°	1·26	1·69	125	0·70	304	0·21	over 1000	—	—	—	—	—	—	—	—	—	—
120°	1·68	1·27	170	0·28	770	—	—	—	—	—	—	—	—	—	—	—	—

succeeding columns give the partial pressures and volumes of air which is saturated with water vapor at various other vacua, and diagram I shows the volumes graphically. A scale of vacua and temperatures for saturated steam is, for convenience, given at the bottom of the figure.

Air Ratio.—It was mentioned that, as the steam passed through the condenser, it became increasingly rich in air. As this increasing air richness reduces the rate of transfer of heat from the steam to the water, it is desirable to show it graphically, and diagram II has been prepared from diagram I for this purpose. The scales of volume and temperature at the left hand side and bottom respectively of the diagram, are the same as in diagram I, as are also the lines representing the approximate ratio of air to steam. In diagram II, it will be seen that, as the vacuum lines are followed to the right and upwards, the ratio of air to vapor falls, and. if the lines were continued to an infinite height, the ratio of air to vapor would be zero, i. e., the fluid would be saturated steam. The (vertical) temperature lines representing the boiling points of water at various vacua are therefore asymptotic to the vacuum curves. For example, the temperature ordinate for 85 degrees is asymptotic to the vacuum line for 28.8 in., as the boiling point of water at 28.8 in. vacuum is 85 degrees Fahr. The vacuum curves have been broken towards their upper ends to bring them into coincidence with their asymptotes, the top ratio curve, situated above the broken parts. representing saturated steam to a scale of volumes given at the right-hand side of the diagram.

For any steam condenser the varying condition of the fluid when passing through it from steam inlet to air exit is obtained by following down the vacuum curve representing the vacuum in the condenser; starting on the diagram from practically saturated steam, the curve is followed until a point is reached determined by the air pump, the relative capacity of the latter per pound of air being indicated by the vertical scale of volumes.

Capacity of Air Pump.—The necessary capacity of the air pump, therefore, depends on the point at which the air and steam are withdrawn, and a withdrawal far down on the vacuum curve would involve a relatively small air pump. But, as the transmission of heat through the metal of the condenser tubes from the steam to the water depends on the difference of temperature between these fluids, it is necessary, in order to obviate the necessity of unreasonably large condensers, to withdraw the air and vapor before the temperature of the mixture falls unduly. Hence it can be said that, for a given condensing surface and given steam and circulating water conditions, there is a limit in air ratio below which the mixture should not be carried; and this limit determines the minimum capacity of air pump necessary per lb. of steam in order to condense the required amount of steam per square foot of cooling surface at the required vacuum.

Effect of Air.—Even with an air-pump capacity in proportion to the amount of air gaining access to a condenser, the efficiency of the condensing surface must be adversely affected by increased quantities of air passing through, because the opportunities for contact of the steam with the tube surface are thereby reduced. In connection with the variation in the condensation rate with varying air richness, the most noteworthy experiments are those of Jas. A. Smith, made in Australia, the results of which are given in a paper read by him before the Victorian Institute of Engineers in 1905; but, as in these experiments the steam had little velocity and there was no air pump, the conditions were very favorable to the accumulation of a film or zone of air around each condensing tube. In the absence of other experiments, it is impossible to give figures for the effect of air richness on the condensation rate in condensers working under vacua usual in steam engine prac-

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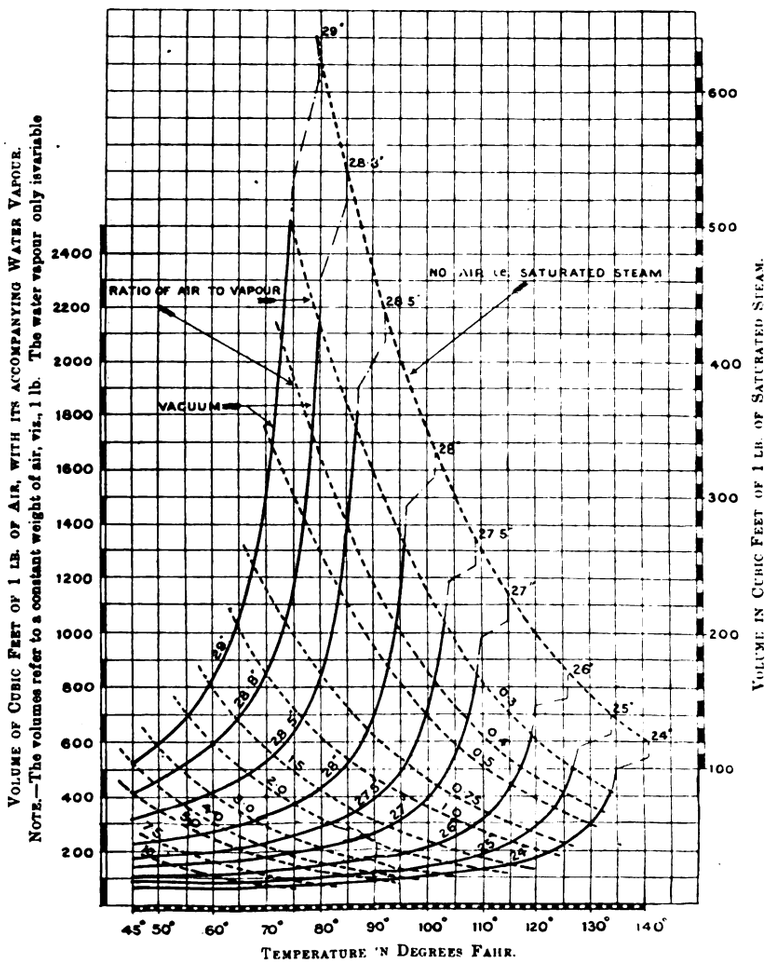
DIAGRAM II.

AIR SATURATED WITH WATER VAPOUR.

CURVES SHOWING RELATION BETWEEN VACUUM, TEMPERATURE, VOLUME, AND RATIO OF AIR TO VAPOUR.


VOLUME OF CUBIC FEET OF 1 LB. OF AIR, WITH ITS ACCOMPANYING WATER VAPOUR.
NOTE.—The volumes refer to a constant weight of air, viz., 1 lb. The water vapour only is variable
VOLUME IN CUBIC FEET OF 1 LB. OF SATURATED STEAM.
RATIO OF AIR TO VAPOUR
NO AIR i.e. SATURATED STEAM
VACUUM
TEMPERATURE IN DEGREES FAHR.

tice, but the fact is established that increased air leakage is always associated with decreased heat transmission through the tube surface.

Ineffective Condensing Surface.—If the air pump capacity is not increased in proportion to an increase in air leakage, the lower rows of tubes automatically become ineffective for condensing purposes, and this so reduces the effective surface that a decrease in vacuum is required, and ensues in order to re-establish the necessary equilibrium.

Consider, for example, a mixture of steam and air at a vacuum at 28.5 in. at the bottom or exit end of a condenser through which the circulating water makes its first pass. If the relative proportion of air and vapor by weight are as 0.3 to 1, a reference to diagram II will show that the temperature of the mixture is about 87 degrees; but, if the air gaining access to the condenser is increased without a corresponding increase in the pump capacity, so that at the bottom of the condenser there are equal weights of air and vapor, the temperature is only 78 degrees, and, if the weight of air is twice that of the vapor, the temperature is only 68 degrees. With circulating water entering the condenser at, say, 60 degrees, and having a mean temperature in the first pass through the lower rows of tubes, of say 63 degrees, 62 degrees, and 61 degrees, respectively in the three cases, the difference in temperature between the condensing water on the inside and the air and steam on the outside of these condenser tubes is 24 degrees, 16 degrees and 7 degrees, respectively, and, as with unflooded tubes the transmission of heat is very nearly proportional to this difference of temperature, the great effect of the quantity of air on the capacity of the condenser will be apparent.

Flooded Tubes.—The above statement was, it will be noted, qualified by the expression "with unflooded tubes," because, with tubes heavily flooded by steam water showering from the top, as is the case in a condenser of ordinary design, the air and steam cannot get access to the tubes; but make the contact with this steam water which cannot be at a less temperature than the water within the lower tubes and will, in ordinary cases, as it comes from the upper and hotter portion of the condenser, be at a considerably higher temperature. If the steam water flooding the lower tubes were at a temperature of 77 degrees, then the difference between this and the saturated air would be 10 degrees in the first case considered, and only 1 degree in the second, which is, therefore, barely practicable, the third case being, of course, impossible; so that in a condenser of ordinary proportions and design in which the condensed steam water showers on to the lowermost tubes, the ratio of air to steam by weight at the air pump suction must be less than unity in order that 28½ in. vacuum may be obtained with circulating water at 60 degrees.

Air Effect on Circulating Water.—A fall in vacuum when caused by air leakage does not materially affect the temperature of the circulating discharge water, because the reduction in heat transmission due to the lower temperature in the condenser base is largely compensated for by the greater transmission resulting from the higher temperature at the top; moreover, any difference in the discharge temperature of the condensing water is readily calculable from the increased temperature of the condensed steam water, and is an illustration of how great a change in condenser efficiency when due to the presence of air may be accompanied by a trifling change in temperature of the circulating discharge water.

Air Leakage.—The weight of air entering the condenser with the steam depends on (*a*) the aggregate air leakage into the system at all parts subjected to pressure below atmospheric, and (*b*) the proportion of air contained by the feed water when entering the boiler.

In marine practice minimum air leakage is associated with a steam turbine having tight glands, minimum number of joints all easy of access, and water-sealed connections, and in which no engine other than the turbine exhausts into the condenser; maximum air leakage is usually to be found when a reciprocating engine and all its auxiliaries exhaust into one common condenser; and it is no exaggeration to say that the loss in

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power by the main engine due to air leakage from these auxiliaries often far exceeds their aggregate power, particularly in tropical waters, when the effective size of the condenser is so easily lessened, due to the near approach in temperature between the water within the tubes and the steam and air without the tubes in the lower part of the condenser.

Air in Feed Water.—The weight of air which can enter a boiler with the feed water depends upon the amount of air in solution in the feed water, together with the amount of air added by the feed pump. In marine practice the greatest amount of air results from the use of ordinary marine ram pumps, driven from the air pump crosshead by the main engines, and air is present in minimum amount when the feed pump is independently driven and float-controlled. The weight of air and other non-condensable gas in real or apparent solution in feed water has been the subject of exhaustive investigation by the writer, and the results as affecting marine practice are, broadly, as follows:

Fresh water carried in tanks for use as auxiliary feed contains at atmospheric pressure from fully 2 to 3½ volumes of air per 100 volumes of water. If this water is introduced into the condenser, about 70 per cent to 90 per cent of its air is immediately given off. Water of condensation contains practically no air when withdrawn by a water pump from the upper sections of a vertical type "Contraflo" condenser; but when allowed to shower freely to the bottom of a condenser of ordinary design it absorbs air, the amount depending on the air ratio in the condenser base, and it is further charged to a slight extent in its passage through an air pump. When the entire feed water passes through an air pump, the air in the pump discharge amounts to from 1½ to 2 per cent, depending on the conditions; but, if this water is passed without disturbance into a feed tank and pumped therefrom by a float-control feed pump, it does not take up further air to any appreciable extent. Condensed water discharged by an air pump and repassed into the vacuum does not become supercharged by repeated circulation through the system, but settles down to a permanent charge of about 2 per cent, which is slightly less than the average quantity contained in ordinary fresh water.

TABLE IV.

Free air at 60° F. and atmospheric pressure per 100 cubic feet of water.	Volume of same air at 60° F. and 27 in. vacuum.	Volume of same air at 105° F.* and 27 in. vacuum.	Same air but saturated with water vapour at 105° F. and 27 in. vacuum
Cubic feet.	Cubic feet.	Cubic feet.	Cubic feet.
0·5	5·0	5·4	22·4
1·0	10·0	10·9	44·9
1·5	15·0	16·3	67·3
2·0	20·0	21·8	89·8
2·5	25·0	27·2	114·1
3·0	30·0	32·6	134·7
3·5	35·0	38·1	157·0
4·0	40·0	43·5	179·5

In order to show how this air affects the air pump capacity, Tables IV and V have been prepared. The first column in each of these tables represents the volume of free air per 100 volumes of water; the remainder of each table is self-explanatory, the last column representing the volumes to be dealt with by the air pump.

TABLE V.

Free air at 60° F. and atmospheric pressure per 100 cubic feet of water.	Volume of same air at 60° F. and 29 in. vacuum.	Volume of same air at 70° F.* and 29 in. vacuum.	Same air but saturated with water vapour at 70° F. and 27 in. vacuum.
Cubic feet.	Cubic feet.	Cubic feet.	Cubic feet.
0·5	15·0	15·3	62
1·0	30·0	30·5	124·3
1·5	45·0	45·8	186
2·0	60·0	61·1	249
2·5	75·0	76·4	311
3·0	90·0	91·5	373
3·5	105·0	107·0	435
4·0	120·0	122·2	497

* *I.e.* about 10° F. below the temperature of saturated steam at the same pressure

Air Pump Effect.—Broadly, it may be said that in no type of condenser can the condensing capacity due to its dimensions be maintained, unless the air pump is sufficient to render all the tube surface available for condensing steam; the air pump must, in fact, dominate the condenser under all conditions of normal air leakage as the least insufficiency so reacts on the condenser as to ultimately put out of action a proportion of the entire condensing surface, with the result of a fall in vacuum. This suppression of effective condensing surface is usually at a maximum in tropical waters, and results to some extent from the prevailing practice of adopting the average temperature of home waters as a basis for determining the general proportions of a condensing plant. To obtain relatively high vacua in low temparature water is no evidence whatever that a plant is correctly designed; and, in order to obtain maximum average efficiency at all temperatures within the usual range, it is necessary to proportion the tube surface, circulating water, and air pump for the highest temperature conditions in which a ship may be required to steam, and this is particularly the case in turbine engined war vessels, because failure to obtain the best vacuum for a given weight, space occupied, and pumping power is equivalent to a definite sacrifice of either power and speed or radius of action.

Air Measurement.—A condensing plant may be said to be in an ideal condition when the only air in the system is that discharged into the boiler in solution with the feed water, but in general practice there must of necessity be considerable air leakage associated with every plant,

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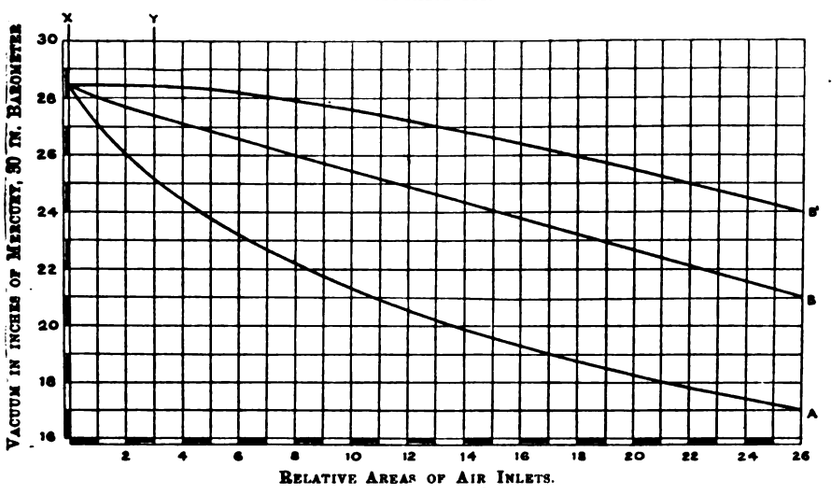
the amount being largely determined in any given case by the condition in which the plant can be maintained with average attention by those in charge. This may be termed the normal leakage of the plant, and to reduce it to a basis of cubic feet of air at atmospheric pressure per unit of time has long been the desire of all those interested in the problem of steam condensation under vacuum. Apparatus to achieve this object has lately been devised, and already it has proved of great assistance in the investigation of this subject, and will undoubtedly be of great utility in ordinary practice. By its use a minimum normal air leakage may be obtained and maintained, as any additional leakage, however small, is immediately indicated; so that air pumps can in future be proportioned for an air leakage which by experience has been proved to be the normal for any given plant, instead of by the haphazard methods now frequently adopted, which so often lead to disastrous effects on condenser efficiency.

Take, for example, the case of a fleet of destroyers of practically identical machinery design; it is at present quite impossible to ascertain or compare the air leakages in the various units, or to determine what is the normal air leakage and whether the air pump is sufficient. In future, however, a fair normal can be established, and thereafter adopted as a basis for all boats of a particular class. The writer's experience of the apparatus used in connection with a Parsons turbine at Hartlepool has been that what was formerly considered to be a fair average air leakage has been reduced by fully 50 per cent, and the attendants have no difficulty in maintaining the air tightness, so that the ultimate effect of this invention on turbine economy is obvious; but, whatever the type of engine and whatever the desired vacuum, ability to readily and visibly ascertain the amount of air leakage at any moment must always be associated with definitely improved results.

DIAGRAM III.

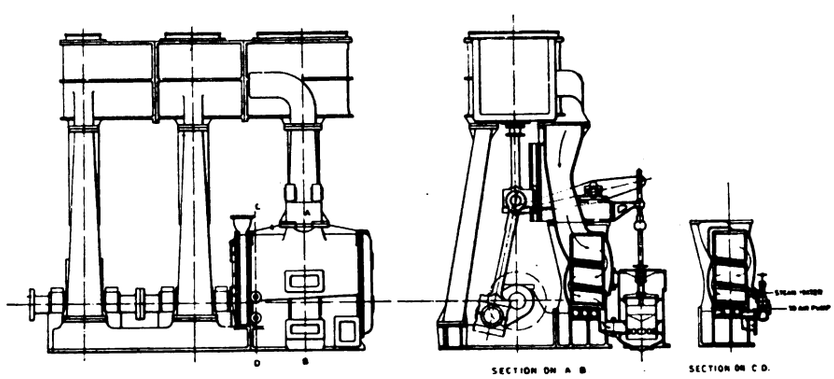


Another valuable feature in the apparatus is that, by mechanically admitting air to a condenser through a graduated valve or otherwise, and observing the discharge necessary to produce a given fall in vacuum, it can at once be seen whether the air pump has a margin in reserve, and its amount ascertained.

Air Pump Capacity.—The writer regrets that it is impossible within the limits of this paper to deal in detail with apparatus for the withdrawal of air, except in so far as air pump efficiency is affected by condensers. The effect of capacity of a given air pump being determined by the amount of pressure reduction created within its barrel relatively to the pressure in the condenser, it follows that the temperature of the water discharged by the pump determines the limit of such reduction, because on the pressure-reducing stroke the contained water evaporates immediately the boiling point is reached. So instantaneous is the evaporation and condensation on the pressure-reducing and pressure-increasing strokes of an air pump that, in some experiments made by Fred Edwards with an Edwards pump having a glass barrel, the glass became alternately dull and clear with a rapidity which the eye could scarcely follow.

Reference to Diagram II will show how inappreciable is the effect of increase in volumetric capacity of air pump when the temperature at its suction approaches the temperature corresponding to the vacuum, and how great is the effect when the temperature difference increases. An ordinary condenser and air pump form an unfortunate combination in this respect, as any increase in load is followed by higher temperature feed water, and consequent reduction in air pump effect, just at the time when greater capacity is desirable. In this connection it may be observed that such a design of condenser as will insure a maximum and uniform air richness at the air pump suction allows of the employment of an air pump of minimum capacity, so that any design in which the line of flow from the steam inlet to the air outlet represents a zone of maximum temperature cannot be conducive to air pump efficiency. Whenever conditions permit, it is obviously technically correct practice to withdraw the condensed steam water and the air and vapor by separate pumps, thereby obtaining thermal and air pump effects quite unattainable when with ordinary air leakage an air pump alone is used, and, as the importance of

Fig. 1



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this question is realized, future development will undoubtedly be along these lines. An air pump should be of such proportions as will render the lowermost tubes in a condenser effective for condensing steam under normal conditions of air leakage, and with the maximum temperature of circulating water, and beyond this there should, whenever possible, be a margin for contingencies.

Fig. 2.

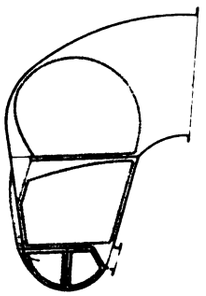


Fig. 3.

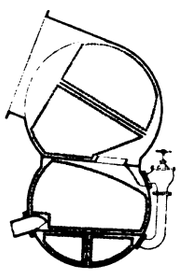


Fig. 4.

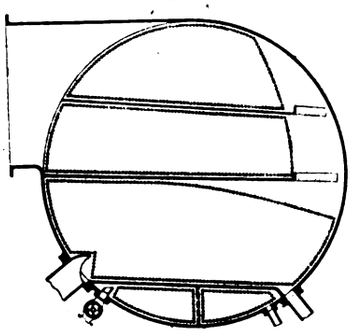


Fig. 5.

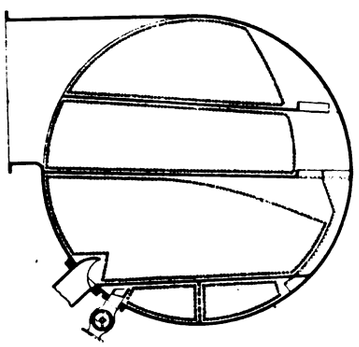


Fig. 6.

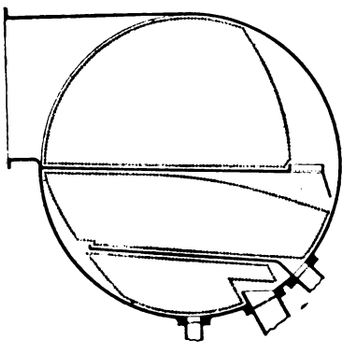


Fig. 7.

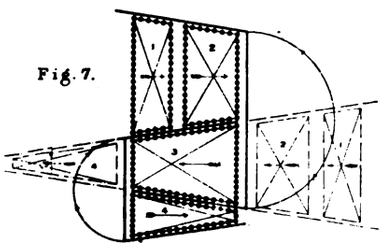
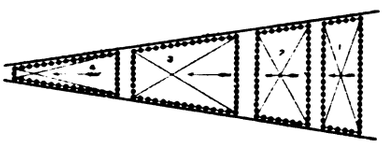


Fig. 8.



Air Pump Efficiency.—Diagram III is based on actual results obtained from a series of tests made on air pumps, but is somewhat sharply defined for purposes of explanation. The two pumps represented by A, B, were of equal size and standard of workmanship, but different types. They were tested with a condenser connected direct to a boiler, and air to a predetermined amount was admitted by mechanical means. The vertical scale on the diagram represents vacuum and the horizontal increasing quantities of air admitted. Steam and condensing water were constant throughout the tests, nothing being altered except the areas for air admission. With no air admission both pumps produced the vacuum corresponding to the temperature conditions in the condenser, viz., 28½ in. On the opening of the smallest air port the vacuum with pump A fell quickly, and with the largest port open the fall amounted to 11½ in. or to 17 in. Under the same conditions the vacuum with pump B fell much more slowly with the small port open, and with the largest port open the fall was 7½ in. or to 21 in. Neither pump was capable of maintaining the full vacuum when even a very small quantity of air was admitted, but the difference in air-withdrawing efficiency between the two types of pump is very definite.

Lowering Feed Water Temperature.—In land installations it is common practice to allow all the feed water to accumulate in the condenser bottom, and so form an open well or pond through which the cooling tubes pass. This is with the object of increasing the effective capacity of the air pump by lowering the temperature of the water passing through it; but, when conditions are such that the air pump is sufficient, the assistance of a cooler is not required; so, with the object of giving flexibility to the air pump capacity, and thereby conserving heat in the feed water, the system shown in Fig. 1 (Plate I) has been devised.

Controllable Cooling System.—The condenser illustrated is one of the "Contraflo" vertical type as applied to the triple-expansion engines of a cargo boat. The cooler is situated in the base of the condenser, from which it is separated by a diaphragm, and is normally kept quite filled with water. When there is a sufficiency of air pump capacity, as will generally be the case in cold waters, all the steam water passes directly to the air pump in the ordinary manner and at a high thermal value, the only effect of the cooler being to advantageously lower the temperature of the condenser bottom; but when in tropical waters, or in the event of abnormal air leakage, the whole or any desired proportion of the feed water may be passed through the cooler, the amount depending on requirements, so that of the total range of the cooler, only such a proportion of it is used as will prevent the air pump from prejudicially reacting on the efficiency of the condenser. Referring again to Diagram III, the application of the cooler system to pump B has a marked effect, and the results are shown by B′. Not only are the vacua very appreciably higher throughout, but the pump has now an actual margin in capacity as represented by x, y, and is able to maintain the full vacuum under all air leakages within that margin. The horizontal x, y may, therefore, be termed air pump reserve due to the cooler, and this reserve need only be drawn on as and when required. The general effects produced are of such technical interest that exhaustive tests are now being made and the results will be dealt with on some future occasion.

Figs. 2 and 3 (Plate II) illustrate the system applied to the condensers of turbine-engined destroyers, and, as in this case, the highest vacuum is always desirable, the whole of the steam water from the upper section passes through the cooler.

Fig. 4 illustrates a battleship condenser, so arranged that the steam

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water is withdrawn by a water pump at the highest possible thermal value, and in a state of minimum aeration. The water necessary for the air pump passes through the cooler and the pump system in continuous circulation, any surplus being bye-passed into the steam space of the condenser. This arrangement, besides resulting in very high thermal efficiency, gives considerable flexibility to the main air pumps, as the constant and uniform water supply naturally promotes a great regularity in working, and admits of a high range of speed when occasion requires. Alternatively, this condenser may be arranged with a controllable cooler, as in Fig. 5, in which case a separate water pump is not required. Fig. 6 illustrates a condenser without a combined cooler, and in which the flow of steam promotes maximum and uniform air richness at the air-pump suction. It is impossible to standardize condensing plants, however, as every proposition must be based on the particular conditions prevailing.

All these condensers embody the distinguishing features of the design, viz., maintenance of uniform flow at right angles, both to the axes of the tubes and to the falling streams of condensed steam water, the depth of fall being determined by the area necessary for the flow of steam between the rows of tubes, and small relatively to the length of flow from the steam inlet to the air outlet. Fig. 7 shows in section a vertical "Contraflo" design having four water passes, and Fig. 8 is the corresponding horizontal arrangement. The latter has been found very convenient for experimental purposes, as, if the base is divided up into cross channels each separately drained, facilities are afforded for the measurement of the rate of condensation on any row or group of tubes.

The writer has found it very difficult to crowd into a short paper the experiences of a very prolonged research in connection with this subject; and, with a view to avoiding repetition, it has been assumed that this contribution will be read in conjunction with the paper on condensers submitted to this institution in 1906.

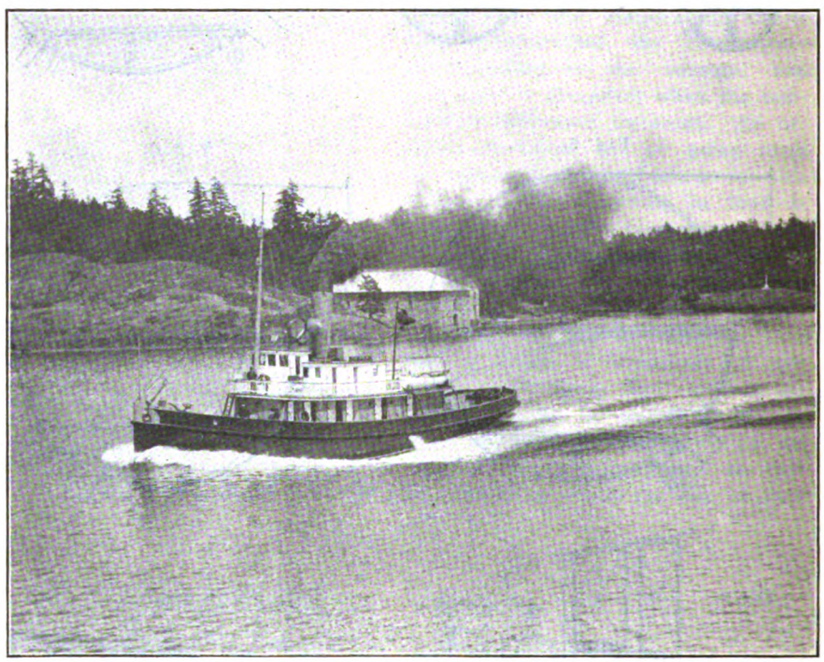
In conclusion, the writer desires to record his thanks to Professor Weighton and the research staff at Armstrong College, Newcastle, and to R. M. Neilson and to other members of Messrs. Richardsons, Westgarth's technical staff at Hartlepool, for their assistance in the preparation of this paper.

TOWBOAT NANOOSE.

The steel towboat Nanoose has recently been built for the Canadian Pacific Railway Co. for towing their car scows between the railroad terminals at Vancouver, B. C., and Vancouver Island. The vessel was built by the B. C. Marine Railway Co., Ltd., at Esquimalt, V. I. The scantlings are to Lloyds rules for class 100 A1. She has four watertight bulkheads, and to prevent panting when working under heavy strain, the side stringers are carried through bulkheads to the bows, and there connected with heavy plating to form breasthooks. She is a single bottom craft with bar keel, straight stem and elliptical stern; length between p. p., 115 ft.; breadth molded, 24 ft. 6 in.; depth, 15 ft.; draft, 12 ft. 7 in. Displacement when fully equipped for sea, with 100 tons bunker coal, and 20 tons fresh water, is 465 tons. One pole mast and light spar is fitted; she carries two 13 ft. carvel built lifeboats equipped to Canadian government regulations, carried under davits of special construction for dropping outboard.

The main engines are compound surface-condensing, also built by the B. C. Marine Railways Co. Cylinders, 17 in. x 40 in. diameter, stroke 27 in. The propeller is of cast iron, 11 ft. diameter, 9 ft. 9 in. pitch; this drove the vessel a speed of 12 knots per hour over a course of 9.45 knots, on the trial trip. The boiler is of the Scotch multitubular type, 14 ft diameter, 12 ft. long; built to Lloyds rules for a working pressure of 150 lbs. There are three Morrison furnaces with separate combustion chambers. The boat is fully equipped with steam deck machinery, consisting of windlass towing engine, steering gear; the Chadburn reply telegraph has pedestals both on the bridge and aft deck.

The electric installation is very complete. In addition to the lights for rooms, cargo clusters and signal lamps, there is a 16 in. searchlight fitted. The dynamo is direct current 5 K. W.; the wiring conforms to the national board of fire underwriters, class F.



TOWBOAT NANOOSE.

A large party of ladies and gentlemen assembled at the trial trip on July 7. The builders were represented by Messrs. Hy Bullen, president, and J. Hardy, chief draughtsman, of the B. C. Marine Railway Co., and the owners by Capt. Troup, general superintendent of the C. P. R. coastal service.

The contract for the construction of a retaining wall and pier at the navy yard at Philadelphia, Pa., has been awarded to the Lawler Bros. Construction Co., of New York, on its bid of $53,777.

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COMMENT ON AMERICAN SCOUT CRUISERS.

The London *Times* prints a very interesting article on the three new scout cruisers of the United States navy, the Birmingham, the Salem and the Chester, the former being fitted with reciprocating engines, the second with Parsons turbines, and the last with turbines of the Curtis pattern. In other respects than the machinery the three vessels are nearly identical. In its comparison the *Times* says:

"On the four hours' full speed trial the Birmingham attained a mean speed of 24,325 knots, with 191.66 revolutions per minute, and 15,540 indicated horsepower. The Salem attained a mean speed of 25.947 knots, with 378.39 revolutions per minute, and a "shaft" horsepower — ascertained by using a torsion meter—of 19,200 horsepower. Allowing 10 per cent for engine friction the corresponding indicated horsepower of reciprocating engines which would have been required to drive the Salem at this speed would have been 21,100 horsepower, and the consumption of coal per indicated horsepower per hour would have been 1.81 pounds, as against a consumption of 1.92 pounds for the Birmingham. The turbines, therefore, gave an increase of 1.62 knots in speed, and an increase in (equivalent) indicated horsepower of nearly 5,600 horsepower—or about 36 per cent—with a small economy in coal consumption.

"Another contract trial of greater practical importance than the full speed trial of the American scouts was that for 24 hours at a speed of about 22.5 knots. The Birmingham averaged 22 2/3 knots with 172 revolutions per minute developing 10,760 I. H. P. and burning 1.91 pounds of coal per I. H. P. per hour; she ran 2.47 knots per ton of coal burned at this speed. The Salem averaged 22.536 knots with 312.5 revolutions per minute, the shaft horsepower was 9,340 horsepower (corresponding to about 10,275 I. H. P.), the coal burned was 1.78 pounds per I. H. P. per hour, and the ship ran 2.73 knots per ton of coal burned. In the case of the Chester the shaft horsepower was not measured, but she averaged 22.78 knots for 24 hours, with 473.5 revolutions per minute, and ran 2.82 knots per ton of coal burned. This trial represents continuous steaming at sea in favorable weather; starting with bunkers full (1,250 tons), the distance which could be covered before coal was exhausted would be about 3,500 knots. This is a good coal endurance for vessels of the dimensions, and is far superior to that of the British scouts.

"Another 24 hours' trial was made at 12 knots, the cruising speed for the class. The Birmingham averaged 12.23 knots, developing 1,600 I. H. P., with 91.4 revolutions per minute, burning 2.89 pounds of coal per I. H. P. per hour and running nearly six knots per ton of coal burned. The Salem averaged 11.93 knots, with 164.1 revolutions per minute, burning 2.68 pounds of coal per estimated I. H. P., and running 6.6 knots per ton of coal burned. The Chester averaged 12.2 knots with 250 revolutions per minute, and ran 6.68 knots per ton of coal burned; she is fitted with cruising turbines. It is interesting to note that both the turbine-propelled vessels surpassed the Birmingham in economy of coal consumption, even at this low cruising speed when only 8 to 10 per cent of the maximum engine power was developed.

"In the design of these vessels and their propellers full use has been made of modern experimental methods. Models were tested in the experimental tank at Washington to determine the "tow-rope" resistance and "effective horsepower" corresponding to various speeds. Every man was taken to secure efficient propellers. For the Salem four competitive designs for propellers are said to have been obtained, including one from this country and another from Germany. Photographs taken of the wave phenomena surrounding the vessels when running their full speed trials furnish evidence that the form and dimensions adopted were admirably well-suited for the high estimated speeds.

"As matters stand the United States navy possesses for the moment the two swiftest, most powerfully armed, and best sea-keeping scout cruisers afloat in the Chester and Salem; and the builders—the Bath Iron Works and the Fore River company—deserve hearty congratulations on their unqualified success."

H. M. S. INDOMITABLE.

The magnificent run which H. M. S. Indomitable has just made as shown that the new battleship cruiser is capable of speeds hitherto unattainable in any navy, with the exception of such craft as torpedo boat destroyers. It is impossible to give precise particulars of a performance concerning which no official information has been supplied. Broadly stated, her passage from Quebec to this country was made in five and a half days, but the number of hours has not been made public nor the rate at which she came down the St. Lawrence. All that can be said is that leaving Quebec early on Wednesday morning, the 29th ult., the Indomitable for the 719 miles down the St. Lawrence river had to steam at a comparatively low speed. At Belle Isle, on the Newfoundland coast, the race home commenced, and the run across the Atlantic was covered at an average speed variously stated as 25.13 and 24.8 knots. For four hours a speed of 26.4 knots was attained. The great speed at which the cruiser has steamed across the ocean is made all the more remarkable by the fact that this vessel has not been stripped in order to allow her to make a record run. She carried the heavy guns of a Dreadnought, a thick coat of armor, her magazines full of ammunition, and all the rest of the equipment of a man-of-war ready for active service. Her cost was enormous, approaching close upon £2,000,000, and before the year is out, another two of these vessels will have been added to the strength of the navy. The Indomitable is 560 ft. long on the water-line, 78½ ft. beam, and has a displacement of 17,250 tons. Her propelling machinery consists of Parsons' turbines, capable of developing 41,000-horsepower. She is one of a new group of cruisers, mainly intended for the convoying of fast merchant steamers should war break out. It is stated that on the measured mile she attained a speed of 28 knots. But the official reticence concerning her performance is complete. Steam is supplied by Babcock boilers, made in Glasgow. Probably the most interesting question which she has settled is her steaming range at full power. This may be taken at, in round numbers, 2,500 knots. Her bunkers hold 3,000 tons of coal; how much more she carried, or whether she carried any addition at all, has not been stated. She is, we believe, fitted to burn oil fuel. We understand that she reached Cowes at 9:40 p. m. on Monday with empty bunkers. Now, it is not likely, that her machinery used less than 15 lb. of steam per horse per hour. Even that figure stands for a very fine performance. If her boilers evaporated 10 lb. of water per pound of coal, we have 1½ lb. of coal per horse per hour, or, say, 60,000 lb., or 27 tons per hour. If her actual steaming time was 132 hours, then she must have burned 3,564 tons on the trip. Two or three hours more or less will not make much difference. Some allowance may perhaps be made for the run down the St. Lawrence. If she had only 3,000 tons of coal to burn then she must have been helped by oil fuel, or her turbines did not exert 40,000 horsepower. In the latter case the efficiency of the ship as a whole is remarkable. Her propellers must be admirable, and the form of the hull under water reflects the greatest credit on her designer. No doubt, in process of time,

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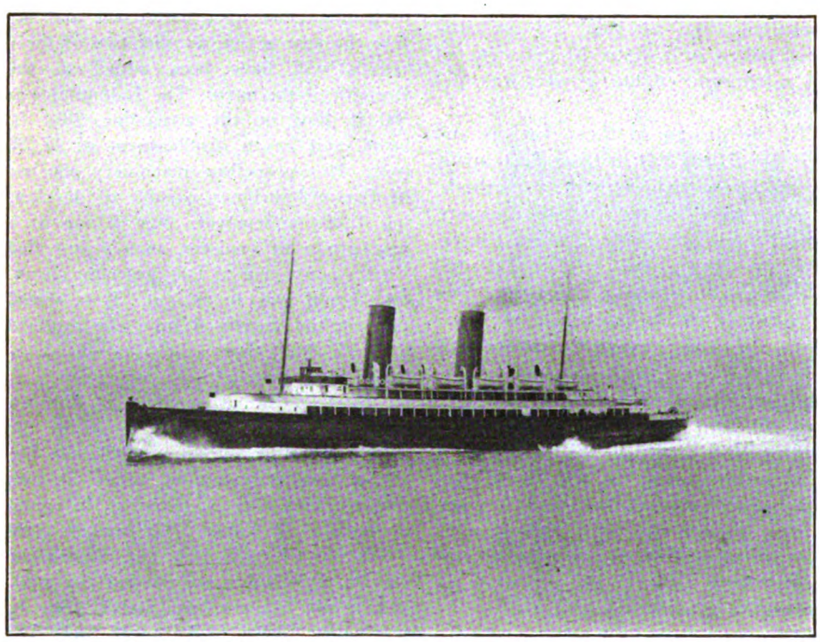
the facts of the case will leak out. It is not impossible that they may be published abroad first. From the purely scientific point of view, the performance of the ship is so full of interest, alike to the naval architect and the engineer, that it will be matter for much regret if the publication of the main features of the Indomitable's performance are withheld for any considerable time.—*Engineer.*

TURBINE STEAMER BEN-MY-CHREE.

What can rightly be described as the largest and fastest cross channel steamer engaged in actual trade yet built is the new Isle of Man turbine steamer Ben-My-Chree, which has been just completed for the service between Liverpool and Douglas, Isle of Man. She is certainly Britain's fastest steamer engaged in the home trade. She has been built by Messrs. Vickers, Sons & Maxim, of Barrow, and is 390 ft. long, 46 ft. broad, and has passenger accommodation for no less than 2,700. She is driven by three turbines of the Parsons type which are arranged to work in series, with one high pressure ahead turbine driving the center shaft and two low pressure turbines, one on each wing shaft. She has five decks, but the promenade deck is the ideal one from the passenger's point of view, for it provides the amplest of space for enjoying the sea passage of 75 miles. It extends for over two-thirds of the vessel's length, and is carried out to the ship's side, while above it is a boat deck extending for one-half of the vessel's length. Steam is supplied from four large double-ended boilers. Her contract speed is 24 knots, but on her trials she did 26.64 knots for fully one-half of her long distance run, having at the same time the tide and wind in her favor. Taking the whole long distance sea trial run, in a fairly heavy sea, she maintained from start to finish an average speed of 24.56 knots which to the builders and owners is highly gratifying, as they have every reason to believe that when things have settled down into comfortable working order she will be generally able with ease to exceed in service her contract speed of 24 knots. In order to facilitate quick maneuvering, a bow rudder as well as the stern rudder has been fitted to the ship.



TURBINE STEAMER BEN-MY-CHREE.

Another feature is that the hull is minutely subdivided, and the doors of the watertight bulkheads are operated by mechanism which is under immediate control of the captain. Safety appliances too, are in excess of ordinary practice. Special tanks, into which water may be pumped, will trim the ship so as to reduce pitching motion, and bilge keels are also fitted to minimize rolling motion.

The secretary of the treasury has accepted the bid of Lee Kimball, of $2,775, for the purchase of the revenue cutter Dexter.

FIRST COMBINATION TURBINE STEAMER.

Messrs. Wm. Denny & Bros., Dumbarton, launched on Saturday, Aug. 15, the twin-screw steamer Otaki, which they have built to the order of the New Zealand Shipping Co., Ltd., London. The machinery of the vessel consists of a combination of reciprocating engines and turbines. The principle of the experiment is that the steam is first admitted to each of the triple-expansion engines, which drive the twin screws, and then passes to a center turbine driving the center screw before reaching the condenser. In this way fuller advantage is taken of the expansion of the steam. The Otaki will be placed on the service between London and New Zealand, being intended for the owners' extensive frozen meat trade. The dimensions of the vessel are: Length, 464 ft. 6 in.; breadth, 60 ft.; and depth, 34 ft. A feature of her equipment is the refrigerating apparatus, enabling variations of temperature to be obtained, suitable to the various classes of perishable cargo. Although not primarily intended for passenger service, she will take a board of trade passenger certificate. The propelling machinery is being supplied by Messrs. Denny & Co., engineers, Dumbarton. The Otaki is the first vessel yet launched for this kind of engine. From the new departure a very considerable economy is expected, and scientific calculators are so accurate nowadays that there is no doubt but that these expectations will be realized.

The lawyers of the steamboat inspection service and customs at New York have been wrestling with the question as to whether a boat tied to a stake in 2½ ft. of water is moored or anchored, and the decision of the board will affect the owners of 2,000 or more power boats in that vicinity, as the law requires a vessel under 150 ft. in length to carry a light when at anchor. There is a penalty of $250 for violating this article.

The Toronto branch of the Navy League has offered a prize of $400 for the best essay which shall be submitted on the subject "Shall Canada Have a Navy of Her Own?" One of the objects of the competition is to bring home to Canadians a sense of their dependence on, and interest in, the naval strength of the Empire, and to press upon public attention the need for a Canadian naval defense force.

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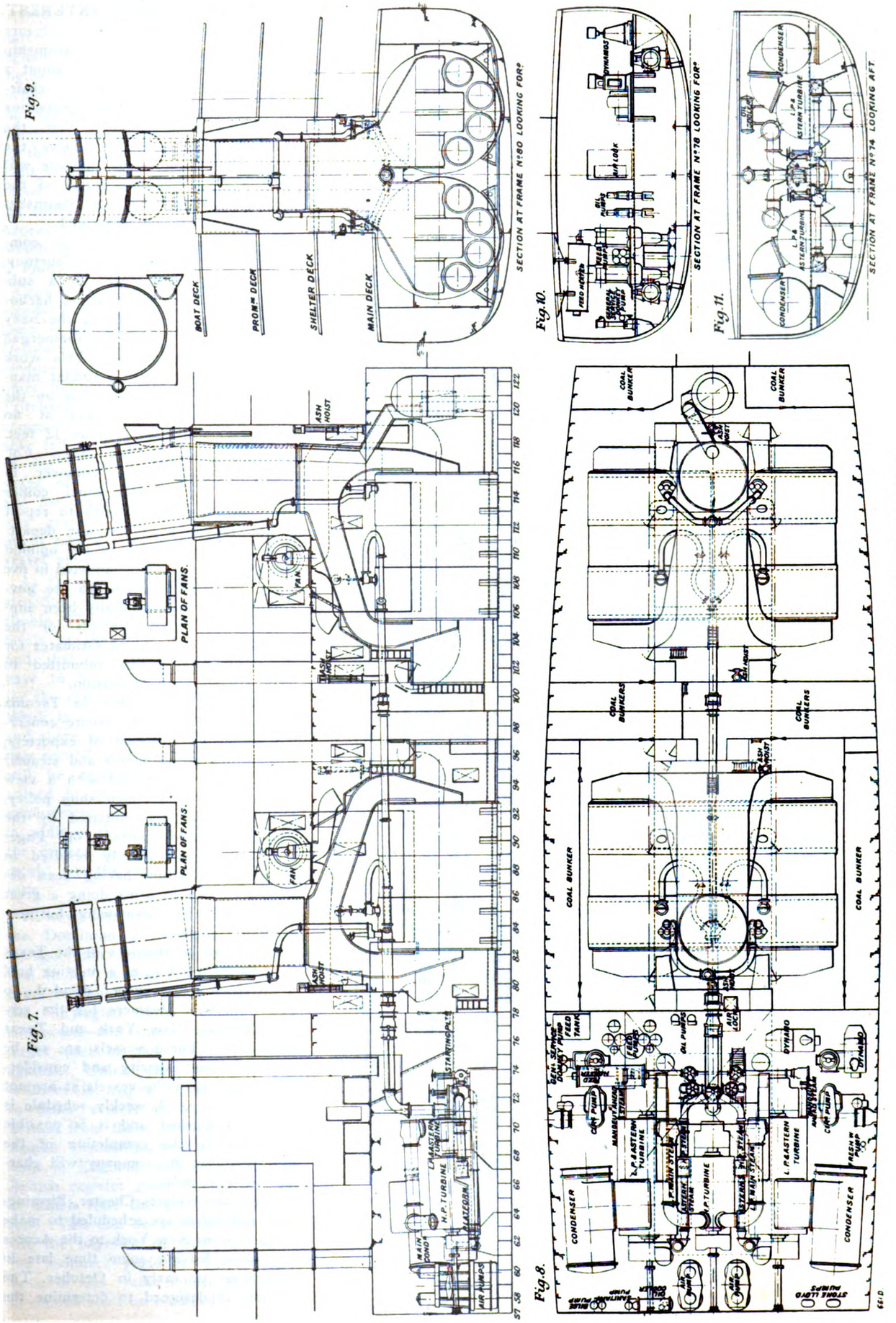

DRAWING OF MACHINERY OF TURBINE STEAMER BEN-MY-CHREE.

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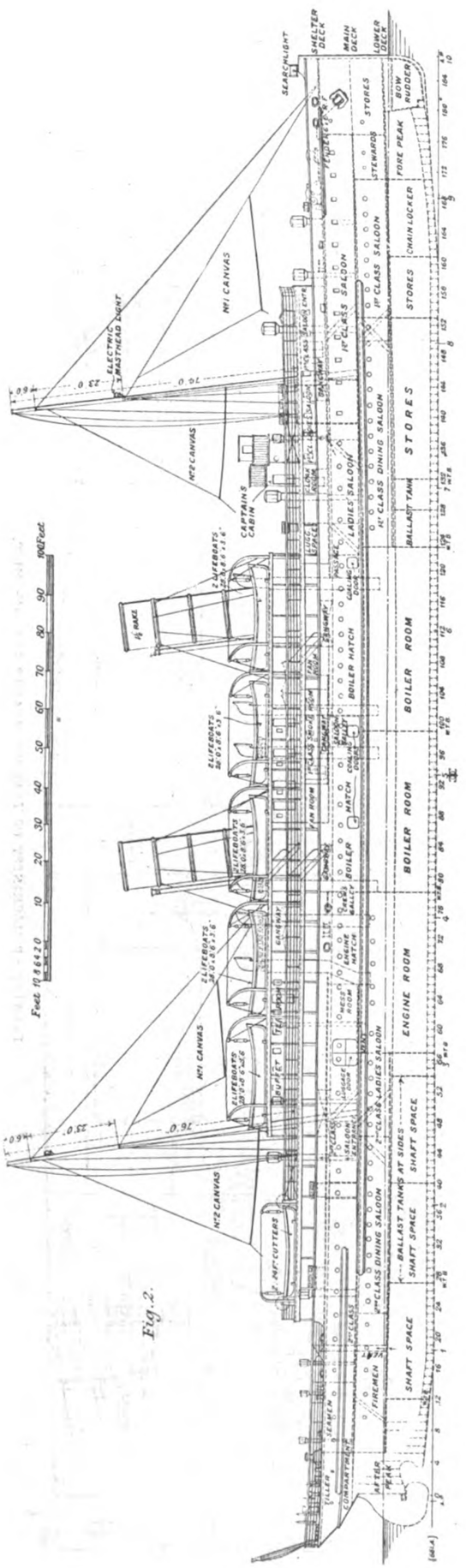

Fig. 2.

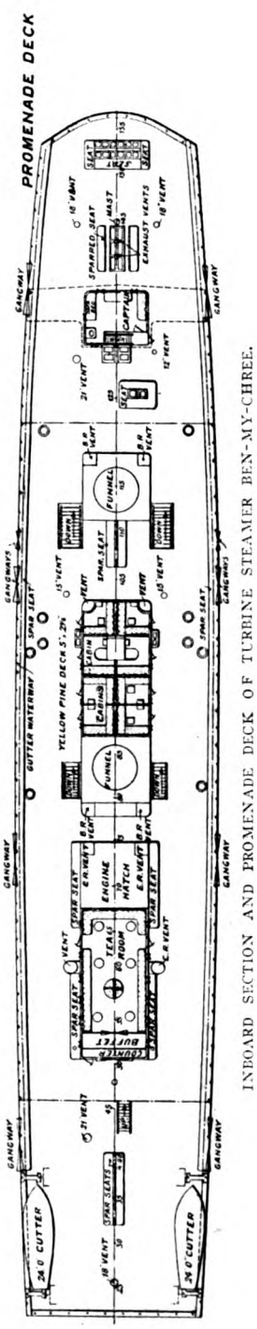

Fig. 3.

INBOARD SECTION AND PROMENADE DECK OF TURBINE STEAMER BEN-MY-CHREE.

ITEMS OF GENERAL INTEREST.

It is expected that the foreclosure sale of the Consolidated Steamship Lines Co. will take place in about a month. Mr. Alvin W. Krech, chairman of the bondholders' protective committee, said recently that the bondholders had yet to receive the final decree, after which the sale will be held. The ultimate status of the Metropolitan and Eastern Steamship companies is as yet undecided.

The submarine Octopus, in command of Lieut. Charles E. Courtney, was recently maneuvered in a submerged condition in Newport harbor for the purpose of enabling the navy department to work out submerged chartings for future use. This work is to be carried out in a similar manner in every important harbor on the Atlantic. The Octopus was at no time nearer the surface than 12 feet.

It is expected that when Col. George W. Goethals, engineer in charge of the Panama canal, comes to Washington next month to report to the secretary of the war department, he will give it as his opinion that the canal can be completed in five years, at much less cost to the government than had generally been supposed. One of the objects for the visit is the discussion of estimates for the next year, to be submitted to Congress at the next session.

Steps have been taken in Tacoma and Seattle, Wash., to secure concerted action on the part of exporters, wharf owners and agents and steamer owners of Puget Sound with a view to maintaining the open shop policy. The movement was initiated by the Shipowners' Association of Puget Sound, and has already resulted in a strong ultimatum having been delivered to certain firms doing a great amount of the stevedoring business at those ports.

The board of directors of the Texas City Steamship Co., at a meeting held in Galveston recently, decided to build five new steamers for the service between New York and Texas City, Tex. These vessels are to be of 4,500 tons capacity and considerably larger than the vessels at present in this service. A weekly schedule is to be established and it is possible that pending the completion of the new steamers the company will charter other vessels.

The scout cruisers Chester, Birmingham and Salem are scheduled to make a cruise from New York to the Azores and back, leaving some time late in September or early in October. The journey is designed to determine the

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relative merits of each vessel in the matter of fuel economy. The Birmingham is equipped with reciprocating engine, the Chester with a Parsons turbine, of English manufacture, and the Salem with a Curtis turbine, of American manufacture. It is said to be the intention of the navy department to have the commander of each vessel maintain a sped of 22 knots on the entire trip from New York to the Azores. On the return voyage the vessels will make trials at 20, 15 and 12 knots, respectively.

Capt. J. B. Watt, the veteran commander of the Cunard liner Lusitania, is to retire from the service in October. He is at present the commodore of the Cunard fleet, in which office he will be succeeded by Capt. Pritchard of the Mauretania. The command of the Lusitania will probably fall to Capt. Dow, now skipper of the Caronia. Capt. Watt is 66 years of age—three years over the age for retirement—but an extension was granted him in order that he might take the command of the finest vessel afloat.

As the time for beginning the construction of the new 20,000-ton battleship Florida draws near, the officials at the New York navy yard find that part of building 115 will have to be razed so that the ways for the ship can be lengthened 110 ft. Work is to be begun in two months and there is reason to believe that a new record in American ship building will be established. The work involved in the construction will give employment to hundreds of men and in addition there is a year's work on the cruiser Baltimore, and almost as much on the battleship Massachusetts.

It now develops that the effort of the Dominion government to debar foreign built vessels from participation in its coasting trade is likely to come to naught—at least in so far as the Norwegian tramp steamers are concerned—and these constituted the larger part of the class legislated against. Unless the Dominion government is willing to go so far as to debar vessels registered in Great Britain from these privileges the Norwegian steamships, most of which were built in England, will be changed to British register prior to Jan. 1, 1909, at which time the act is to take effect. This can be accomplished without the payment of duty and leaves the steamers perfectly free to continue in this traffic unless the order-in-council shall be modified.

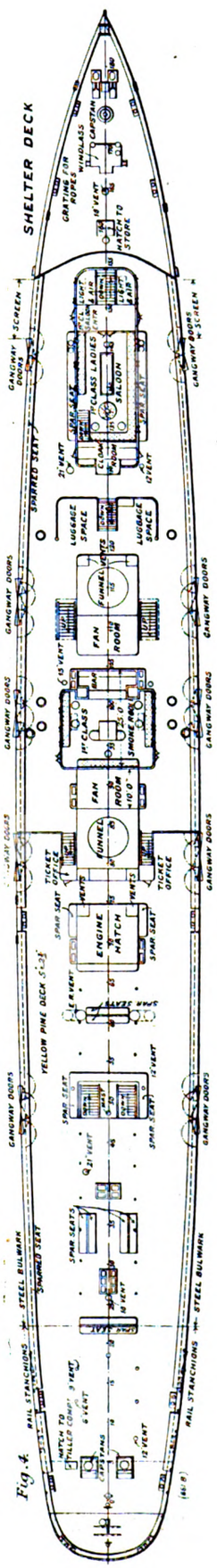

Fig. 4.

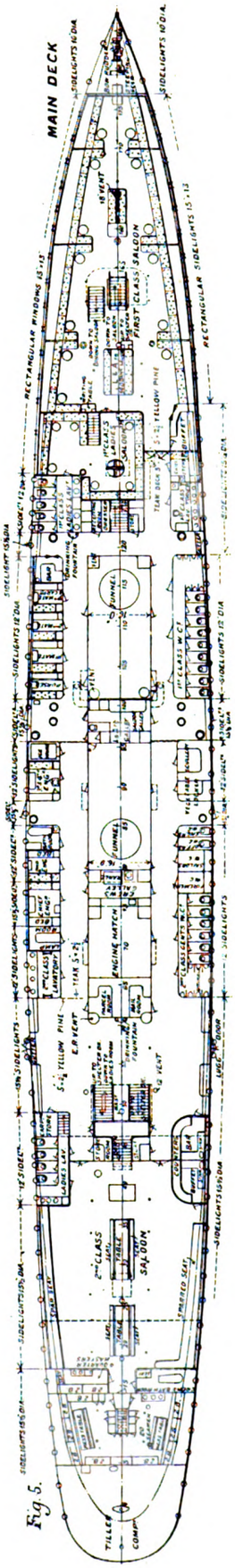

Fig. 5.

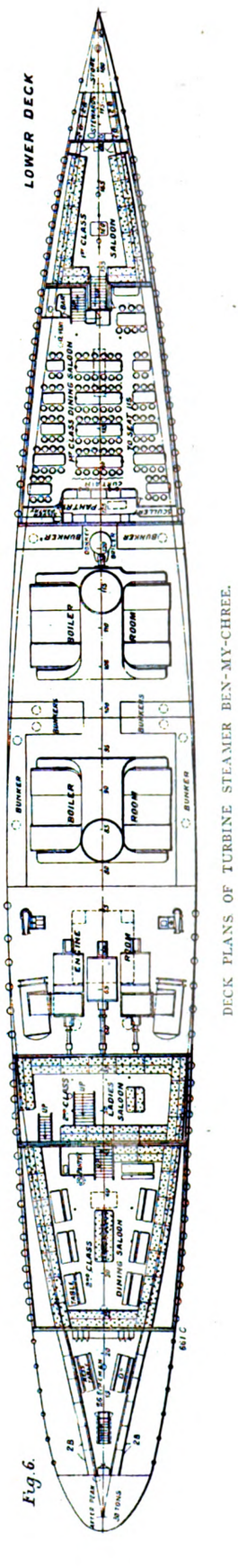

Fig. 6.

DECK PLANS OF TURBINE STEAMER BEN-MY-CHREE.

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Two Notes on Ship Calculations.*

BY W. S. ABELL.

The first note consists of a discussion of the various methods used in ship calculations, including a new rule for finding areas, etc., with a considerably less number of ordinates than is usually employed.

The second note gives a method of constructing an approximate metacentric diagram, within an error of about 1 per cent, when only the length, breadth, draught, displacement, and tons per inch are known.

METHODS OF SHIP CALCULATION.

As a first step in finding the approximate area of a figure bounded by a curve on the one side and by straight lines at the other side and ends, a function can always be found which will coincide with the given curve in any desired number of points.

In general the form of the function is given by—

$$y = a_0 + a_1 x + a_2 x^2 + \ldots + a_{2n-1} x^{2n-1}.$$

This form involves $2n$ constants, which can be so determined that the function and the given curve coincide in $2n$ points. In the process of finding the area of the given figure, the assumption usually made is that the area is the same as that under the function which coincides with the given curve in $2n$ points.

It is fairly obvious that, unless the given curve is, mathematically speaking, "smooth," *i. e.*, free from sudden changes of slope and curvature, the difference between the true and approximate areas will be large; so that, in such cases, the area cannot be approximately calculated by a function *passing through* the point where this sudden change of slope occurs, *i. e.*, this point should be the termination of the approximate integration.

Ship curves are of two general kinds—the horizontal sections or water planes, which are "smooth" curves, and the vertical transverse sections, which are for the lower portion of the depth "not smooth," having a very sudden change of slope at the turn of the bilge. It therefore follows that, to avoid error, the approximate integration can only be carried out from the top water line down to the turn of the bilge. This limitation is in accordance with usual practice, the lower portion, or keel appendage, as it is termed, being separately calculated, and for like reasons the forward and after extremities of the ship are treated in the same manner.

In order to calculate the main portion of the displacement, bounded vertically by the top water line and a water line near the turn of the bilge and horizontally by sections near, but not at, the ends of the ship, the usual practice is to divide the length and depth into a comparatively large number of equal parts, the number for the length being about 20 and for the depth about six. The assumption usually made is that, for each pair of spaces which include three ordinates, the function approximating to the given curve is a second degree parabola,

$$y = a_0 + a_1 x + a_2 x^2.$$

It is contended that, as the function is only assumed to coincide with the given curve over a small portion of the figure, the error introduced is smaller than would be the case if the function were assumed continuous over a greater length. This contention does not appear altogether logical, because great care is taken to prevent irregularities in the form of a ship, *i. e.*, to make the curves "smooth" or fair, and it seems reasonable to infer that the lines of a ship are given fairly accurately by a general function of the type indicated.

The first practical recognition of this fact appears to have been due to Tchebyscheff, who gave a general formula for the lines of a ship, and who also worked out his rule for approximate integration on the same assumption. This rule, as is well known, fixes the ordinates to be used for integration in such a manner that the area of the curve is given by the sum of the ordinates.

To consider the general case: In the function taken there are $2n$ conditions to be satisfied, and this can be done in a number of ways, *e. g.*:

(*a*) The positions of the ordinates may be fixed, in which case the number of ordinates will be $2n$, and the quantities which are determined from solution of the equations involved are the multipliers of the ordinates, which are $2n$ in number. A special case of this type is the ordinary Simpson's rule, in which the ordinates are fixed, one at each extremity of the area, and the remainder at equal intervals.

(*b*) The multipliers may be assumed equal to each other, which is one condition; there are therefore $(2n - 1)$ more conditions to fulfil, which can be satisfied by determining the positions of $(2n - 1)$ ordinates. This is Tchebyscheff's rule; the multipliers all being equal, the area is, therefore, given by the sum of the ordinates.

(*c*) As $2n$ conditions have to be fulfilled, and as a reduction in number of ordinates generally means a reduction in calculation, the conditions can also be satisfied by taking n ordinates and n multipliers, the positions of the ordinates and the values of the multipliers being found from the general equations. It follows that by this method n ordinates should give the same approximate area as $2n - 1$ Tchebyscheff ordinates, *i. e.*, practically half the number.

As regards this third method, Professor Burnside, F. R. S., of the Royal Naval College, Greenwich, first calculated for me the positions of the ordinates and the values of the multipliers, and afterwards found that the results had been previously worked out by Gauss and published in Todhunter's Functions of Laplace, Lame, and Bessel in 1875. The table at the end gives the positions of the ordinates and the values of the multipliers for different numbers of ordinates, as originally calculated by Gauss; Professor Burnside checked the results up to five ordinates. The theoretical considerations for finding the multipliers and positions of ordinates are given in Appendix I.

Judging from previous experience with Tchebyscheff sections, it was considered that nine of these ordinates would be sufficient for all, or nearly all, calculations, and on this basis five Gauss ordinates should give the same degree of accuracy.

The multipliers are rather unwieldy, but it was found that these could be replaced by an approximate form, *viz.*, 5, 10, 12, 10, 5, without any appreciable loss of accuracy. Further, with this rule, sections occur at mid length, at approximately quarter length, and near the ends, giving a good general idea of the form of the ship.

An examination of the accuracy of Simpson's, Tchebyscheff's and Gauss's methods was then undertaken. The form of ship used was one which had been worked out a large number of times by several individuals, so that it was possible to practically eliminate the personal error in the calculations. Further, the results were compared in particular cases with in-

*Read at Institution of Naval Architects.

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tegrator calculations, which give absolutely accurate results.

In ship calculation, the process is arranged in such a manner that, to obtain the desired result, the integration is reduced to finding the area of a curve of some kind. The starting point of all calculation is from the ordinates of a water line or transverse section, and the fact that the final curve is seldom, if ever, plotted, may lead to serious error, because it is not known if the shape of the curve involves any serious change of slope.

To illustrate the point that all calculations reduce in effect to finding the area of a curve, suppose it is desired to calculate the vertical position of the center of buoyancy. The arrangement of the ordinary displacement sheet is such that the sum of vertical columns gives functions representing the area of water planes. To obtain the vertical position of the center of buoyancy, each function of water plane area is multiplied by its distance below the top water plane, the products being integrated by Simpson's multipliers. The sum of these functions then gives the total moment of the displacement below the top water line. The essential part of the calculation is that a curve of moment of areas of water planes has been constructed, and afterwards integrated by Simpson's rules.

The first step was, therefore, to ascertain if any of the derived curves used in the process of approximate integration would have any serious irregularity, bearing in mind the fact that the original curve was supposed "smooth."

The underlying integrations for all the usual calculations are given in Appendix II, and the shapes of the various derived curves are shown in Figs. 1 and 2 (Plate I).

From the theoretical considerations given, and from the figures, it will be seen that in only one case was there any probability of departure from the "smooth" condition, and that was, unfortunately, in a very important one, viz., calculating the height of the transverse metacenter above the center of buoyancy.

It therefore follows that for all calculations, except that referred to, a function of the general form indicated, should give the results as closely as by the usual methods.

This probability was checked by actual calculation, taking the usual degree of accuracy, *i. e.*, that the true and approximate results should agree within a maximum error of ½ per cent. For all calculations, except the one specified, the desired result was given by the following arrangements of ordinates:

Simpson's rule, 13 transverse sections, 5 water planes; Tchebyscheff's rule, 9 transverse sections, 5 Simpson water planes; Gauss' rule, 5 transverse sections, 5 Simpson water planes; Gauss' rule, 5 transverse sections, 3 Gauss water planes.

The fact that five Gauss transverse sections gave as good a result as nine Tchebyscheff sections shows that the theory advanced is confirmed by fact.

To apply Gauss' rule to practice, it it is to be observed, *e. g.*, no ordinate occurs at the top water plane, and it is desired to know nearly all the properties of this particular plane. It therefore appears advisable, for this and other reasons, to have the water planes evenly spaced, and consequently the method to adopt appears to be

Fig. 1.

SHAPE OF FUNCTIONS FOR WATER PLANE CALCULATIONS

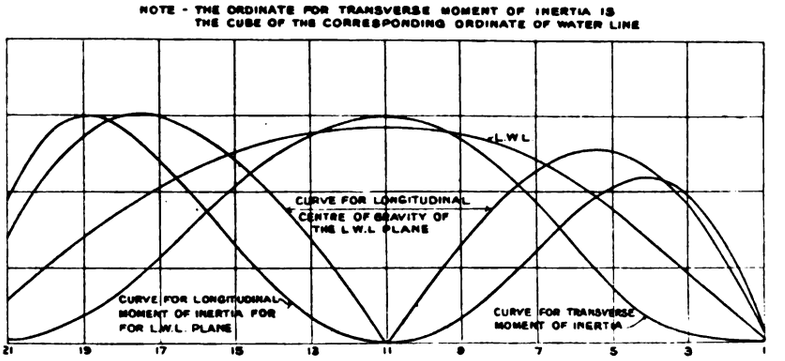

NOTE - THE ORDINATE FOR TRANSVERSE MOMENT OF INERTIA IS THE CUBE OF THE CORRESPONDING ORDINATE OF WATER LINE
L.W.L.
CURVE FOR LONGITUDINAL CENTRE OF GRAVITY OF THE L.W.L. PLANE
CURVE FOR LONGITUDINAL MOMENT OF INERTIA FOR FOR L.W.L. PLANE
CURVE FOR TRANSVERSE MOMENT OF INERTIA
21 19 17 15 13 11 9 7 5 3 1

Fig. 2.

SHAPE OF FUNCTIONS FOR CALCULATION OF DISPLACEMENT & CENTRE OF BUOYANCY

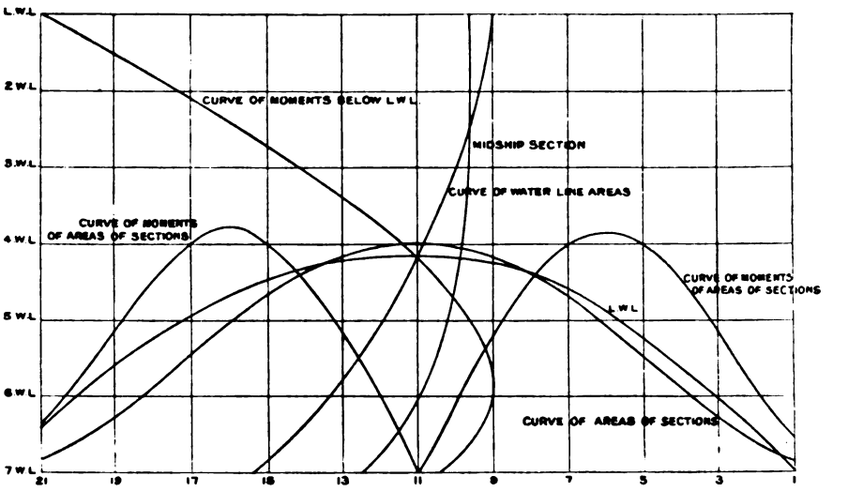
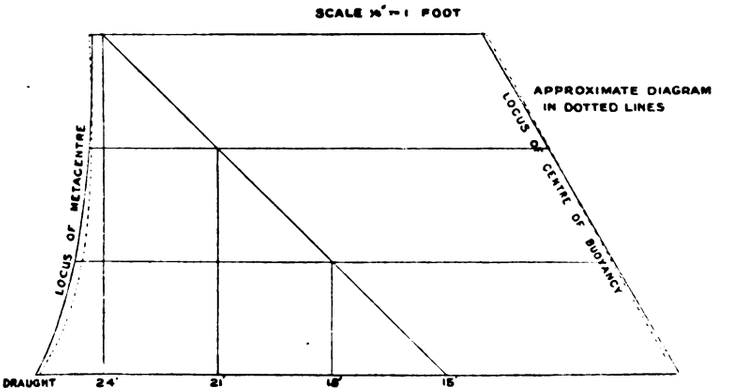


Fig. 3.

METACENTRIC DIAGRAM (IN FULL LINES)

SCALE ½" = 1 FOOT



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Gauss transverse sections in association with Simpson water planes.

It has been stated before that one Gauss section is at the middle of length, but the four other sections will have to be constructed. It is suggested that, in addition to the usual sections shown in a body plan, these Gauss sections should be drawn in dotted, as they afford a ready means of calculation of displacement, etc., when the ship is in a damaged or otherwise unusual condition.

Before devising a tabular form for the displacement sheet on these lines, the question of the calculation of the transverse metacenter was considered. It has been shown in Appendix II that if n ordinates are necessary to find the approximate area of a water plane, then, for the same degree of accuracy, $(3n-1)$ ordinates would theoretically be required to find the transverse inertia of the water plane. The statement above that five Gauss sections are necessary for length, refers, of course, to calculation of displacement, center of buoyancy, etc.; but, if the water plane only is being considered, three Gauss ordinates would probably give good results. It therefore appears that, apart from considerations of great slope, at least eight Gauss ordinates are required to give the transverse inertia.

As a result of calculation, it was found that, in order to get the calculation sufficiently accurate, it was necessary to use either—

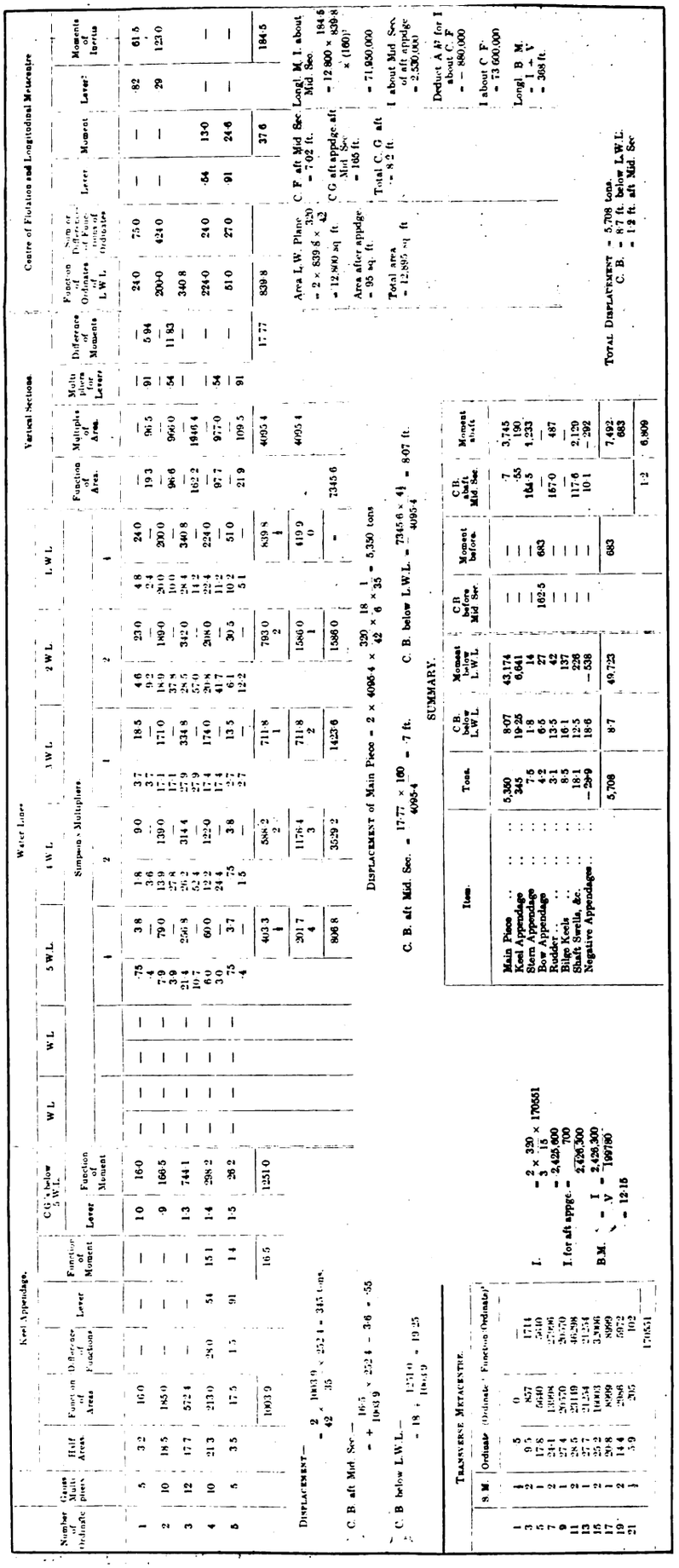
Simpson's rule .....11 or 13 ordinates.
Tchebyscheff's rule ..10 ordinates.
Gauss' rule ..... 8 ordinates.

It is much easier to use Simpson's rule, with 11 ordinates evenly spaced with or without 2 half ordinates at the ends, than to construct new Gauss sections. The reason of the apparent inconsistency appears to be due partly to the fact that a Simpson ordinate occurs near each discontinuous point, and partly because the area of the part of the curve before and abaft the discontinuous points is a small fraction of the total area.

Plate II shows a displacement sheet embodying Gauss' rule, which shows a considerable saving in labor without any loss in accuracy.

As regards stability at large angles, there is no *a priori* reason why Gauss' rule should not apply. Hitherto, the minimum number of sections used has been 10 Tchebyscheff, or 11 to 13 Simpson; 5 Gauss sections should, therefore, in accordance with the previous remarks, suffice.

In order to further check the accuracy of Gauss' rule, a quite distinct ship form from the previous one was taken, and the stability carefully worked out in the usual


Ft In
WATER LINES APART 4 0
(Ordinates spaced according to Gauss' Rule)
LENGTH BETWEEN PERPENDICULARS 320 0
BREADTH EXTREME 42 0
DRAUGHT OF WATER ... ... Forward 22 0
Aft 22 0
Mean 22 0
Keel Appendage.
Water Lines
Vertical Sections
Centre of Flotation and Longitudinal Metacentre
Simpson's Multipliers
Displacement of Main Piece = 2 × 4096·4 × 320/42 × 6 × 35 = 5,350 tons
C. B. aft Mid. Sec. = 17·77 × 160 = 7 ft. 4095·4
C. B. below L.W.L. = 7345·6 × 41 = 8·07 ft. 4095·4
SUMMARY.
Item. Tons. C.B. below L.W.L. Moment about L.W.L. C.B. before Mid Sec. Moment before. C.B. abaft Mid Sec. Moment abaft
Main Piece 5,350 8·07 43,174 — — — — —
Keel Appendage 345 19·25 6,641 — — — -7 -3,745
Stern Appendage 7·5 1·8 14 — — 162·5 184·5 1,233
Bow Appendage 4·2 6·6 27 — — — — —
Rudder 3·1 13·5 42 — — 683 167·0 487
Bilge Keels 8·5 16·1 137 — — — 117·6 2,170
Shaft Swells, &c. 18·1 12·5 226 — — — 10·1 292
Negative Appendages — 29·9 — 538 — — — —
5,708 8·7 49,723 683 7,492
683
Total Displacement = 5,708 tons.
C. B. = 8·7 ft. below L.W.L.
= 1·2 ft. aft Mid. Sec.
Transverse Metacentre.
I. = 2 × 320 × 170651 / 15 = 2,426,900
I for aft appge. = 700 = 2,426,300
B.M. = I / V = 2,426,300 / 169780 = 12·15

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manner. A new body was made with Gauss sections and cross curves of stability found by means of the integrator. The actual curve of stability so obtained agreed, within the usual limits of error, with the curve found by using the greater number of sections, which latter curve was also checked in certain spots of direct calculation. This test of Gauss' rule, which is certainly more searching than any previous one, may be considered as sufficiently good to justify its general adoption.

The labor of stability calculation is obviously considerably shortened—the actual time involved in working out 4 cross curves, or 16 actual determinations of displacement and arm of the righting couple, being only 2½ hours. There was, of course, in addition, the time required to trace the body and to plot the cross curves; but, in general, it may be said that a complete determination of the statical stability curve is possible with about 3 hours' work.

There is one further point about the displacement sheet, and that is regarding the calculation of the keel appendage, which is shown on the left of the sheet. In order to render Gauss' rule more accurate, it is desirable to imagine the deadwood and cut-up forward filled in to a thickness equal to the width of keel, down to the straight line of keel produced; this being done both for the main piece of the displacement and for the keel appendage especially. With this device Gauss' rule can be used to calculate the keel appendage, and the triangular-shaped parts can be easily deducted in the final summary table.

APPROXIMATE CONSTRUCTION FOR THE METACENTRIC DIAGRAM

The form of construction of the metacentric diagram which is usually employed for warships, the details of which are generally understood, is shown in Fig. 3 (Plate I).

The purpose of this approximation is to enable a fairly accurate (generally within about 1 per cent) estimate of the posltion of the transverse metacentric relative to th ship to be obtained when only the principal dimensions in the ship are known.

Let L be the length, B the beam, and D the draught in feet, Δ the displacement in tons, and T the tons per inch, then—

$\frac{\Delta \times 35}{L \times B \times D} = b$, the "block co-efficient."

$\frac{T \times 420}{L \times B} = a$, the "waterline co-efficient."

In the initial stages of a design, L. B, D and Δ are generally roughly fixed, and it is desirable to know if the beam is sufficient to give the required metacentric height. The usual form of approximation is to give the value of B M, *i. e.*, the distance of the metacenter above the center of buoyancy, as—

$$B M = \text{constant} \times \frac{B^2}{D}.$$

It appears reasonable to suppose that if the value of a is known, a closer approximation would be possible.

In the case of an actual ship, information is generally given regarding the variation of displacement with draught from which a can be determined, and in the design stage a can be inferred from a previous ship.

An investigation, which included a large number of types of warships, was made as to the relation between the transverse radius of gyration of the water line area and the mean breadth, which is a. B, and it was found that, covering a very large range of type,

$$\frac{K}{B} = .2a \times .1, \qquad (1)$$

where K is the radius of gyration. The material for merchant ships was not available, so the constants in the approximate relation could not be determined; but it would doubtless be the form—

$$\frac{K}{B} = m \cdot a + n.$$

The value of B M is given by—

$$B M = \frac{A K^2}{V} = \frac{a . L . B . K^2}{b\ L\ B\ D} = \frac{a K^2}{b D'}$$

and can be at once determined from the value of K obtained from the formula.

The depth h of the center of buoyancy below the waterline is given by Morrish's rule, as follows:

$$h = 1/3\ \frac{\frac{\Delta}{12 T} + \frac{D}{2}}{} = 1/3\ \frac{\frac{b \times L \times B \times D \times 420}{35 \times 12 \times a \times L \times B} + \frac{D}{2}}{}$$

or

$$\frac{h}{D} = \frac{b}{3a} + \frac{1}{6}. \qquad (2)$$

Hence, knowing the values of B M and h, the position of the metacenter relative to the ship is obtained from the particular draught D.

If it is desired to know the position of the metacenter at any other draught, the new position of the center of buoyancy and the new value of B M must be found.

The locus of the center of buoyancy is generally a straight line, and, in order to determine the locus, it is only necessary to know one point, and the slope of the line, which is given by—

$$\tan \theta = \frac{A h}{V},$$

where θ is the inclination to the horizontal, A is the area of the water plane and V the volume of displacement. Substituting for A, V, and h—

$$\tan \theta = \frac{a\ L\ B\ D}{b\ L\ B\ D} \left[\frac{b}{3a} + \frac{1}{6}\right]$$

$$= \frac{1}{3} + \frac{1}{6} . \frac{a}{b}. \qquad (3)$$

From which equation it follows that, since the curve of buoyancy is a straight line for considerable variations of draught, the ratio of a to b is constant for the same region. The position of the center of buoyancy is thus determined for the new draught.

As regards the new value of B M—

$$B M = \frac{I}{V} = \frac{I}{\Delta \times 55},$$

where I is the inertia of the water plane, a quantity which varies little with alteration of draught. The displacement, on the other hand, is a direct linear function of the draught, and can be written $\Delta = p D + q$. If values are substituted in the above equation it becomes—

$$B M\ (p D + q) = \text{Constant},$$

or—

$$B M \times D = \text{Constant}. \qquad (4)$$

Hence, knowing the value of the B M for the original draught D, it can be determined for any other draught by equation (4).

The approximate metacentric diagram is thus fully determined by means of the four equations. Fig. 3 (Plate I) shows for a particular case the approximate diagram, dotted as well as that directly calculated, which is shown in full lines.

While on the subject of the metacentric diagram, a curious point presented itself, which does not appear to be generally known, and that is in respect of the lowest point of the metacenter. As the draught increases, the center of bucyancy rises and the value of B M diminishes. Let $\delta \Delta$ be the alteration in displacement and δ B M the alteration in B M, then, the rise of the center of buoyancy.

$$= \frac{h \delta \Delta}{\Delta},$$

and, from the assumptions used in connection with formula (4),

$$B M \times \Delta = \text{Constant},$$

whence, differentiating,

$$B M \delta \Delta + \Delta \delta B M = 0,$$

or—

$$\delta B M = -B M \frac{\delta \Delta}{\Delta},$$

therefore the rise of the metacenter is equal to

$$\frac{h \delta \Delta}{\Delta} - B M \frac{\delta \Delta}{\Delta} = (h - B M) \frac{\delta \Delta}{\Delta}. \qquad (5)$$

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From equation (5) it follows that, if h is greater than B M, the metacenter rises, or that the metacenter is at its lowest point when $h = $ B M, *i. e.*, when the metacenter is in the waterline. This condition would be expressed by saying that, in the diagram constructed as in the example given, the metacentric locus should be horizontal at the point where it cuts the 45° line. A large number of metacentric diagrams have been inspected, and it is found that this property is generally true, the lowest point, however, occurring generally just before the locus crosses the line.

In conclusion, I have to express my thanks to Professor Burnside, of the Royal Naval College, Greenwich, for considerable assistance in connection with the first part of this paper.

RULES FOR APPROXIMATE INTEGRATION.

Rule.	Simpson.		Tchebyscheff.		Gauss.		
Degree of Function.	Number of Ordinates	Multipliers	Number of Ordinates	Positions of Ordinates *	Number of Ordinates	Positions of Ordinates *	Multipliers.
1st ...	2	$\frac{1}{2}, \frac{1}{2}$	—	—	1	0	1
2nd ...	3	$\frac{1}{3}, \frac{4}{3}, \frac{1}{3}$	2	$\pm .5774$	—	—	—
3rd ...	4	$\frac{3}{8}, \frac{9}{8}, \frac{9}{8}, \frac{3}{8}$	3	0, $\pm .7071$	2	$\pm .5774$	$\frac{1}{2}$
4th ...	5	$\frac{14}{45}, \frac{64}{45}, \frac{24}{45}, \frac{64}{45}, \frac{14}{45}$	4	$\pm .1876$, $\pm .7947$	—	—	—
5th ...	6	$\frac{95}{288}, \frac{375}{288}, \frac{250}{288}, \frac{250}{288}, \frac{375}{288}, \frac{95}{288}$	5	0, $\pm .3745$, $\pm .8325$	3	0, $\pm .7746$	$\frac{5}{9}$, $\frac{8}{9}$, $\frac{5}{9}$
6th ...	7	$\frac{10\frac{1}{2}}{35}, \frac{54}{35}, \frac{63}{35}, \frac{68}{35}, \frac{63}{35}, \frac{54}{35}, \frac{10\frac{1}{2}}{35}$ or Weddle's approximation $\frac{3}{10}(1, 5, 1, 6, 1, 5, 1)$	6	$\pm .2666$, $\pm .4225$, $\pm .8662$	—	—	—
7th ...	—	—	7	0, $\pm .324$, $\pm .530$, $\pm .884$	4	$\pm .3400$, $\pm .8611$	$.3261$, $.1739$
8th ...	—	—	—	—	—	—	—
9th ...	—	—	9	0, $\pm .1679$, $\pm .5288$, $\pm .6010$, $\pm .9116$	5	0, $\pm .5385$, $\pm .9062$	$.2841$, $.2393$ or $.1185$ (approx.)
13th ...	—	—	—	—	7	0, $\pm .4058$, $\pm .7415$, $\pm .9491$	$.2090$, $.1909$, $.1399$, $.0647$

* Positions of ordinates are given as a fraction of half the length, measured from middle of length.

APPENDIX I.

THEORY OF APPROXIMATE INTEGRATION.

As explained in the paper, in order to find the approximate area under a curve, it is assumed that the equation of the curve is given by a function of the type—

$$y = a_0 + a_1 x + a_2 x^2 + \ . \ . \ . \ + a_{2n-1} x^{2n-1} \qquad (1)$$

The problem is to determine the area under this function in terms of a certain number of ordinates of the function.

The equation of the curve, as written above, contains $2n$ constants, which can be determined in such a manner that the function will coincide with the given curve in $2n$ points. The assumption made for purposes of approximate integration is that the area under the chosen function is equal to the area under the given curve, which approximation can only be good as long as the given curve is fairly "smooth."

The area can be expressed in terms of certain ordinates and certain multipliers of such ordinates. Let p_1 be the multiplier and y_1 be the ordinate corresponding to a value $x = x_1$; then, if A be the area,

$$A = p_1 y_1 + p_2 y_2 + \&c.$$

The quantities that have to be determined are the values of the multipliers p_1, and the positions of the ordinates, *i. c.*, the values of x_1.

The function (1) contains $2n$ constants, and therefore the total number of quantities which can be found are $2n$, or, in other words, *the sum of the total number of ordinates and the total number of multipliers must be equal to* $2n$.

The method of determination of p_1 p_2 &c., and x_1 x_2, &c., is as follows:—

$$A = \int y \, dx,$$

and, without loss of any generality, the limits of the integration can be put as + 1 and — 1.

$$\therefore A = \int_{-1}^{+1} y \, dx = \int_{-1}^{+1} (a_0 + a_1 x + a_2 x^2 + \ . \ . \ . \ + a_{2n-1} x^{2n-1}) \, dx$$

$$= \left(a_0 x + a_1 \frac{x^2}{2} + a_2 \frac{x^3}{3} \ . \ . \ . \ + a_{2n-1} \frac{x^{2n}}{2n} \right)_{-1}^{+1}$$

$$= 2 \left[a_0 + \frac{a_2}{3} + \frac{a_4}{5} \ . \ . \ . \ . \ + \frac{a_{2n-2}}{2n-1} \right] \qquad (2)$$

But, by assumption,

$$A = p_1 y_1 + p_2 y_2 + p_3 y_3 + \&c.$$

and, substituting the value of y_1 in terms of x_1,

$$\begin{aligned} A = {} & a_0 [p_1 + p_2 + p_3 + \&c.] \\ & + a_1 [p_1 x_1 + p_2 x_2 + p_3 x_3 + \ . \ . \ . \ . \ ] \\ & + a_2 [p_1 x_1^2 + p_2 x_2^2 + \ . \ . \ . \ . \ ] \\ & + a_3 [p_1 x_1^3 + \ . \ . \ . \ . \ ] \\ & + \ . \ . \ . \ . \end{aligned} \qquad (3)$$

Now the value of the area found in the two ways is the same, and therefore the right-hand sides of equations (2) and (3) must be the same whatever the values of a_0, a_1, a_2, &c., whence

$$\left.\begin{aligned} & p_1 + p_2 + p_3 + \ . \ . \ . \ . \ . = 0 \\ & p_1 x_1 + p_2 x_2 + p_3 x_3 + \ . \ . \ . = 0 \\ & p_1 x_1^2 + p_2 x_2^2 + p_3 x_3^2 + \ . \ . = 2/3 \\ & p_1 x_1^3 + \ . \ . \ . \ . \ . \ . \ . = 0 \\ & p_1 x_1^4 + \ . \ . \ . \ . \ . \ . \ . = 2/5 \end{aligned}\right\} \qquad (4)$$

and so on.

This gives a series of equations whence the values of p_1, p_2, &c., and x_1, x_2, &c., can be determined. There are $2n$ equations, and from these only $2n$ quantities can be determined.

To take the case of Simpson's rule, the ordinates are equally spaced, and, therefore, if there be an odd number of ordinates, one will occur at $x = 0$, and the others will be in pairs symmetrically placed about the middle of length, *i. e.*, with $(2n - 1)$ ordinates—

$$\begin{aligned} & x_1 = -x_{2n-1} = 1; \\ & x_2 = -x_{2n-2} = \frac{n-2}{n-1}; \\ & x_3 = -x_{2n-3} = \frac{n-3}{n-1}; \\ & \ . \ . \ . \ . \ . \ . \ . \ . \ . \ ; \\ & x_n = 0. \end{aligned}$$

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The second, fourth, sixth, &c., of equations (4) then give—

$$(p_1 - p_{2n-1})\,x_1 + (p_2 - p_{2n-2})\,x_2 + \;.\;.\;.\;.\; + (p_{n-1} - p_{n+1})\,x_{n-1} = 0$$
$$(p_1 - p_{2n-1})\,x_1^3 + (p_2 - p_{2n-2})\,x_2^3 + \;.\;.\;.\;.\; + (p_{n-1} - p_{n+1})\,x_{n-1}^3 = 0$$
$$.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.$$
$$(p_1 - p_{2n-1})\,x_1^{2n-3} + (p_2 - p_{2n-2})\,x_2^{2n-3} + \;.\;.\;.\; + (p_{n-1} - p_{n+1})\,x_{n-1}^{2n-3} = 0$$

from which it follows that the coleffi-cients of ordinates equidistant from the middle are equal.

The first, third, fifth, &c., of equations (4) now become—

$$\left.\begin{array}{lll} p_1 + p_2 + \;.\;.\;.\;.\;.\; + p_{n-1} + \frac{1}{2}\,p_n = & 1 & (a) \\ p_1 x_1^2 + p_2 x_2^2 + \;.\;.\;.\; + p_{n-1}\,x_{n-1}^2 = & \frac{1}{3} & (b) \\ .\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;. & & \\ p_1 x_1^{2n-2} + p_2 x_2^{2n-2} + \;.\;.\; + p_{n-1}\,x_{n-1}^{2n-2} = & \frac{1}{2n-1} & \end{array}\right\} \quad (5)$$

This group (5) series of equations gives an easier form for calculation; and, for illustration, take the Simpson rule for three ordinates.

The multipliers are p_1, p_2, p_3, and the positions x_1, x_2, x_3; as above—
$x_1 = -x_3 = 1$, $x_2 = 0$, $p_1 = p_3$.
From equation (5*a*) $2\,p_1 + p_2 = 2$.
From equation (5*b*) $2\,p_1 = 2/3$,
whence $p_1 = 1/3$, $p_2 = 4/3$, and the rule is 1/3 . 4/3 . 1/3.

In this simple case the three multipliers are the only three unknowns, and the curve so assumed to coincide with the given curve is therefore of the second degree.

In the case of Tchebyscheff's rule, the condition is that the multipliers are all equal. This fulfils one condition; there are $(2\,n - 1)$ remaining conditions, which must give the positions of $(2\,n - 1)$ ordinates. It will be found here as before that the ordinates are distributed symmetrically on either side of the middle point, and that the co-efficients are equal in pairs.

In Tchebyscheff's Rule group (4) reduces to

$$\left.\begin{array}{l} (2\,n - 1)\,p = 2. \\ 2\,x_1^2 + 2\,x_2^2 + \;.\;.\;.\;.\; + x_{n-1}^2 = \frac{2}{3p} = \frac{2\,n-1}{3} \\ 2\,x_1^4 + 2\,x_2^4 + \;.\;.\;.\;.\; + x_{n-1}^4 = \frac{2\,n-1}{5} \\ \&c., \&c., \end{array}\right\} \quad (6)$$

whence x_1, x_2, &c., can be determined.

The last case taken is that in which the number of ordinates is the same as the number of multipliers, so that the actual number of ordinates used is as small as possible, there being *n* of each for the general function taken. Here again are found the same conditions as to symmetry of distribution of ordinates and equality of multipliers as before. In the case in which *n* is an odd number, say, $2\,m + 1$, equations (4) become

$$\left.\begin{array}{ll} p_1 + p_2 + \;.\;.\;.\;.\;.\; + p_m + \frac{1}{2}\,p_{m+1} = & 1 \\ p_1 x_1^2 + p_2 x_2^2 + \;.\;.\; + p_m x_m^2 = & \frac{1}{3} \\ .\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;.\;. & \\ p_1 x_1^{4m} + p_2 x_2^{4m} + \;.\;.\; + p_m x_m^{4m} = & \frac{1}{4\,m+1} \end{array}\right\} \quad (7)$$

The solutions of the equations for various rules are given at the end of the paper. For the Gauss five-ordinate rule, an approximation as regards the multipliers is given, which has been found to involve no appreciable error in the integration, and it is this approximation which is used in the examples of calculation given.

APPENDIX II.

SHAPE OF FUNCTIONS USED IN CALCULATIONS.

Water-plane Calculations.—It is generally required to know the area, the longitudinal position of the center of gravity, the transverse and the longitudinal moment of inertia about the center of gravity. The waterline is a "smooth" curve, and may be represented by a function of the general type stated. It remains to be seen whether, in the various calculations detailed above, there is any probability of introducing any serious change of function or change of smoothness.

Let *y* be the ordinate, *x* the distance from mid-length, and let the function be represented by

$$y = F\,(x^{2n-1}).$$

then

Area of water plane ... ... $= \int y\,dx = \int F\,(x^{2n-1})\,dx.$

Moment of area of water plane ... ... $= \int y\,dx.x = \int F\,(x^{2n-1})\,dx.x$
$= \int F\,(x^{2n})\,dx.$

Longitudinal moment of inertia of water plane $= \int y\,dx.x^2 = \int F\,(x^{2n+1})\,dx.$

Transverse moment of inertia ... ... $= \int y\,dx\,\frac{y^2}{3} = \frac{1}{3}\int \left[F(x^{2n-1})\right]^3 dx$
$= \frac{1}{3}\int F\,(x^{3(2n-1)})\,dx.$

Comparing these calculations, it is seen that the degree of the functions assumed for moment and longitudinal moment of inertia calculations, is only one and two degrees higher respectively than that of the original function, and that consequently, the rule which integrates one should approximately hold for all three. The actual shapes of these functions are shown in Fig. 1 (Plate I.), from which it will be seen that there is no point of inflection in the moment function, and a slight point in the longitudinal moment of inertia curve.

As regards the function for transverse inertia, its degree is three times the de-

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gree of the original function, and it would be reasonable to assume a considerable difference of shape. This is at once seen by inspection of the figure, which is not drawn to the same scale; if it were so, then, supposing the maximum ordinate of the waterline were represented by 20, the maximum ordinate of the inertia function would be 8,000, and the effect of the sudden change would be much more apparent. The need to use more ordinates for the integration of this function was found in actual practice, and the means of dealing with the question are given in the body of the paper.

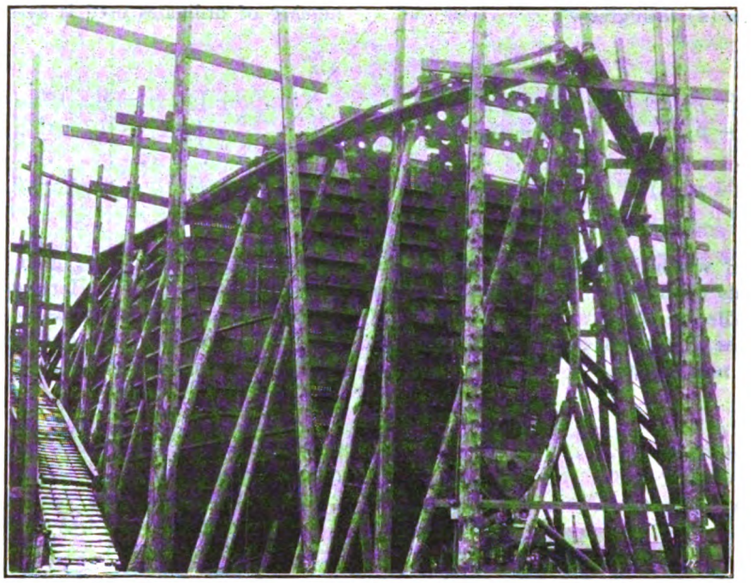
Displacement and Center of Buoyancy Calculations.—The displacement is found in two ways, firstly, by finding the area of various water planes, and then integrating the curve of waterline areas with respect to depth; and, secondly, by finding the areas of various transverse sections, and then integrating the curve of area of sections with respect to length.

The longitudinal position of the center of buoyancy is found by integrating the curve of moments of areas of section with respect to mid-length, and for the vertical position, by integrating the curve of moments of water planes below the load or top waterline.

The actual shape of the functions used in these calculations is given in Fig. 2, from which it will be seen that the curves are free from points of inflection; therefore the shortened rules for integration should be applicable, as was actually found to be the case.

NEW SYSTEM OF SHIP CONSTRUCTION.

Messrs. R. Craggs & Sons, Ltd., launched from their Tees dock yard, Middlesbrough, on Wednesday, Aug. 12, the steel oil tank steamer Paul Paix, built for Messrs. Lennards Carrying Co., Ltd., of which J. Milner Lennard is chairman. The occasion was an important one, as this is the first ship to be built on the Isherwood system of construction. Considerable interest has been evinced in this new system and a brief description of the ship may not be out of place.

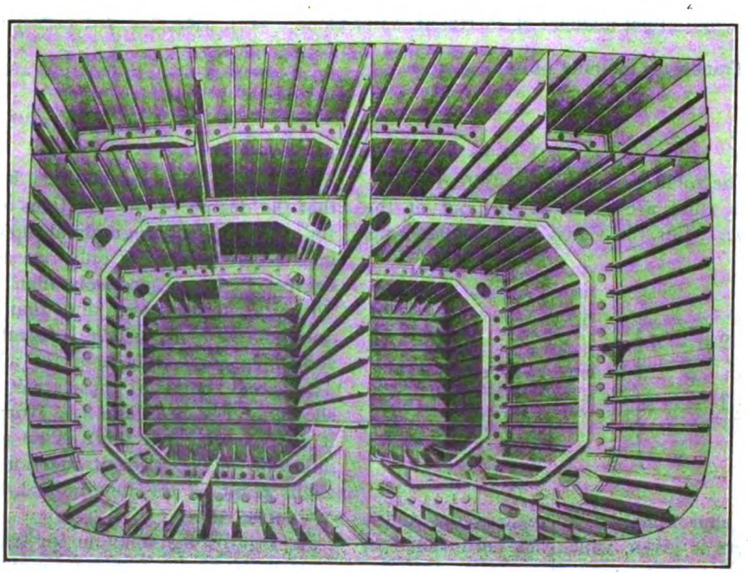


STEAMER PAUL PAIX UNDER CONSTRUCTION.

The dimensions of the vessel are 367 ft. over all, 49 ft. 6 in. beam extreme, and 28 ft. depth molded, and is subdivided in order to form 16 separate oil tanks. The steamer is designed to carry 6,400 tons dead weight and special arrangements are made to enable her to load right down to the full load draught with a cargo of motor spirit with the same facility as with the denser oils.

In the Isherwood system of construction the closely spaced transverse ribs which we are familiar with in ordinary vessels are omitted, and the transverse strength is obtained by fitting on the shell and deck plating a series of strong transverses at widely spaced intervals. These transverses extend completely round the sides, bottom and deck of the ship, and are slotted to allow of longitudinal frames and beams being fitted continuously through the transverses. The new system enables the steamer to be built of greater strength than ordinarily and at the same time the dead weight carrying capacity is considerably increased. The construction is simplified and all parts are readily accessible, thus reducing maintenance repairs to a minimum, and offering greater facility for damage repairs.

In addition to the vessel being constructed on the new system, the general design for which E. Hall Craggs is responsible, differs in some respects from the ordinary oil carrying vessel. The steamer is of the single deck type, having a continuous expansion trunkway above the oil tanks; quadruple expansion engines are to be fitted amidships, and arrangements have been made for three main boilers to be fitted abreast. The coaling arrangements are very simple and very little trimming is necessary, the cross bunker forward of the boiler room being the main permanent bunker. The bridge space is to be



SECTION OF STEEL SCREW OIL TANK STEAMER PAUL PAIX.

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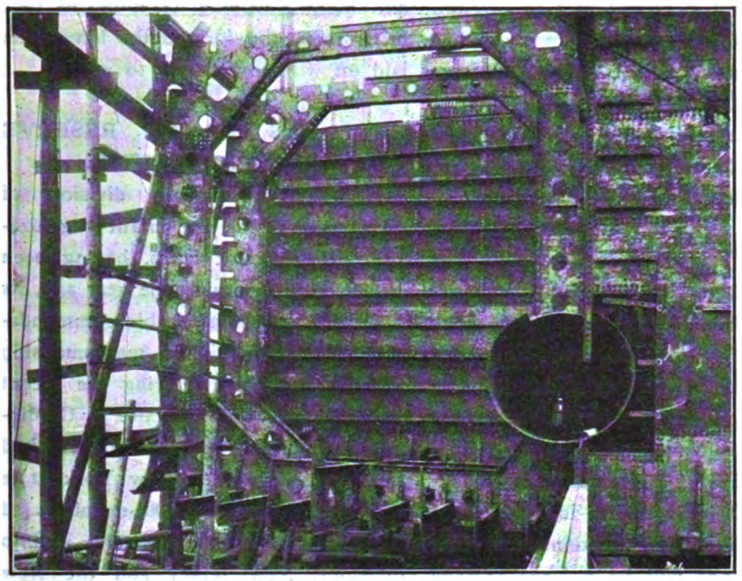


STEAMER PAUL PAIX UNDER CONSTRUCTION.

utilized for reserve bunkers. A double bottom available for carrying oil fuel or water ballast is fitted in the machinery space.

The vessel has been built for the highest classification of three classification societies, viz., Lloyds, British Corporation and Bureau Veritas, and the whole process of tank testing under pressure on the stocks has been carried out with remarkable facility and to the entire satisfaction of all concerned.

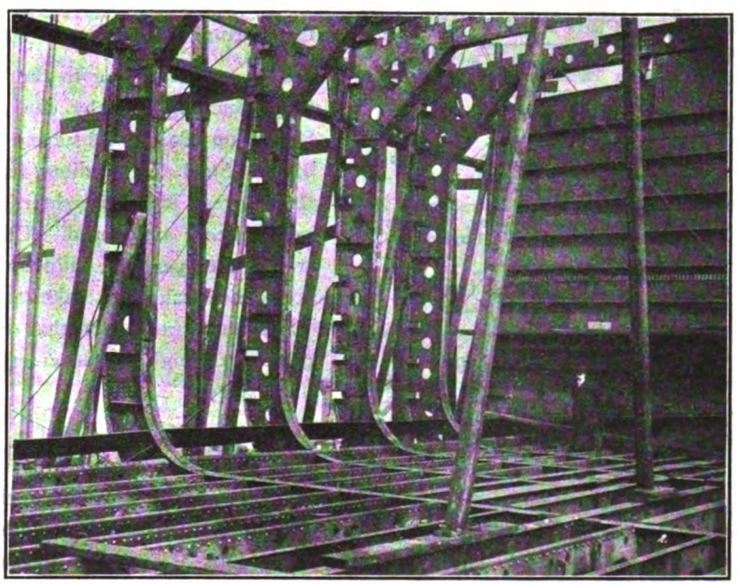
There are two complete cargo pumping installations of unusual power designed to deliver the fuel cargo into shore tanks in the course of a few hours.

Accommodation for ships company is very commodious and complete in every respect.

All details have been arranged in consultation with William Lennard, of Middlesbrough, whose long experience in manipulating the bulk oil trade has been of great value.

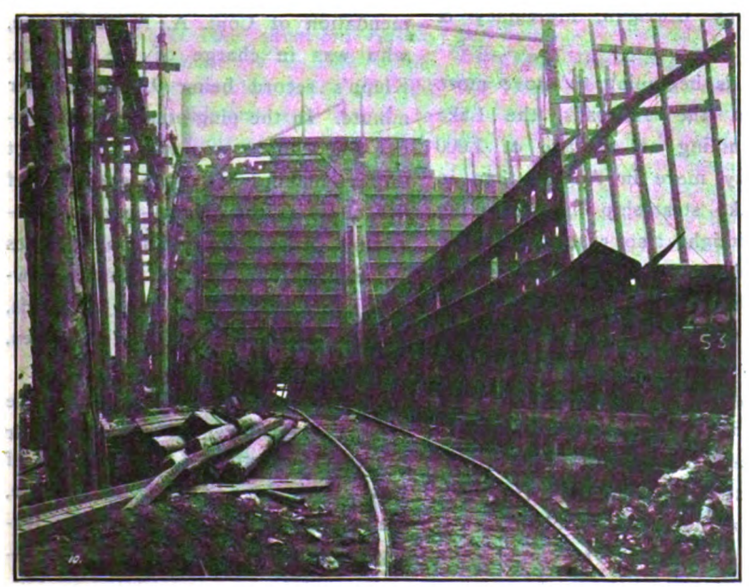
The inspection of hull and machinery has been carried out on behalf of the owners by J. Smaling and J. Marshall, respectively.

A private expedition headed by Dr. Jean Charcot has recently left Havre, France, in the steamer Pourquoi Pas, on a voyage of discovery to the south pole. The leader is accompanied by a number of young scientists on this, his second attempt of the kind. After reaching Alexander's Land the party plans to continue the cruise in a southwesterly direction to explore and



STEAMER PAUL PAIX UNDER CONSTRUCTION.

define the southern limits of the Pacific ocean and to determine accurately whether or not there is a vast continent extending as far south as the pole itself. The expedition is fitted out for three years, but the members expect to live to a great extent on the products of their hunting and fishing. An interesting portion of the equipment are the ice automobiles with which the explorers hope to cover the southern ice fields. They have been used successfully on the snow and ice of the Alps.



STEAMER PAUL PAIX UNDER CONSTRUCTION.

Capt. C. M. Haight, formerly of Wyandotte, has purchased the wooden barge Biwabic for service on the Atlantic. The Biwabic is 241 ft. long, 41 ft. beam and 17 ft. deep, and was built in Marine City.

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SIGNS OF PROSPERITY.

While ore shipments on the lakes are not sensibly increasing, there is indication of better feeling all around. In point of fact, great activity is displayed in the matter of improvements. The most notable departure is the determination of the Steel Corporation to construct its own breakwater at Gary. While improvements in open water are invariably made at government expense, the Steel Corporation apparently prefers to pay the bill rather than suffer the delay incidental to government legislation. Contract has therefore been given to the Great Lakes Dredge & Dock Co. for the construction of a breakwater immediately west of the west pier of the harbor extending 1,000 ft. in a northerly direction, northeast 800 ft. and east by 1,400 ft. This will create a harbor sufficiently capacious to accommodate the largest boats.

The Steel Corporation also through one of its subsidiary companies has given contract to the Wellman-Seaver-Morgan Co. for the installation of four Hulett machines on the Lake Shore side of Ashtabula Harbor. These machines will be the largest of this type ever constructed. The machines will be of 15 tons capacity, the largest hitherto being of 10 tons, and will be about 50 per cent heavier than the machines now in use. They will be equipped with weighing hoppers so that the ore can be weighed as it is loaded into railroad cars. Each machine will have a capacity for unloading 700,000 tons of ore in an average season. Working in connection with the machines will be a large storage bridge covering the dock to be used for storing the ore.

The contract given to the American Ship Building Co. by the Pittsburg Steamship Co., a subsidiary company of the Steel Corporation, for two of the largest sized freighters, has already been announced. Other contracts are pending, illustrating the confidence taken in lake trade, notwithstanding the fact that it is now passing through the severest slump in its history.

Corrigan, McKinney & Co. will erect two new blast furnaces in the upper reaches of the Cuyahoga river, and the Upson Nut Co. is building a concrete dock at its blast furnaces on the Cuyahoga river which were formerly operated by Corrigan, McKinney & Co.

Freight is beginning to move more freely on the railroads, the Lake Shore handling an average of 1,000 cars a day more in August than in July. Lake steamship lines handling package freight also report a greatly augmented movement in iron castings and general building material. In view of this condition the railroads which for some time past have been practically out of the market for new material have been ordering cars.

Doubtless this activity in structural lines is stimulated by the fact that material is low, lower probably than it will be next year. The condition is extremely gratifying, as it means that many men who for months have been laid off will now return to work.

BUFFALO'S NAVAL RESERVE PRACTICE CRUISE.

Although the Buffalo division of naval reserves is the infant organization of the great lakes, having been mustered into service one year ago, its members won considerable commendation for distinguished marksmanship and general ability during the recent exercises and target practice in Gardiner's Bay, where the naval reserves had their annual cruise. New York state was represented by 400 members of the New York, Brooklyn and Buffalo divisions, New Jersey and the New England States mustering the substantial representation of 2,500 men.

The Buffalo division, an aggregation of 56 enlisted men and 5 commissioned officers under command of Lieut. E. C. Sornberger, upon arrival at New York was assigned to the U. S. Auxiliary Crusiser Prairie, the other divisions being assigned to the Auxiliary Cruiser Yankee, submarine craft and torpedo boats which comprised the fleet. The cruise of the reserves commenced with the departure of the vessels from New York on Aug. 8.

In the target practice remarkably good scores were made by the Buffalo men despite the fact that they had no previous instruction in the handling of large guns. The record made by Harvey A. Klupp called forth the commendation of Com. A. A. Ackerman, who was in charge of the practice, Klupp's record being 9.73 shots per minute. In the ping-pong target practice the Buffalo men who had perfect scores—making five bulls eyes out of five shots at the target—were: Boatswain's Mate George Diebold, James W. Reilly, John Latrell, Francis Bowman, Edward Webb, H. J. Davis, Frank J. Fisher and Erwin Koeppen, seamen.

The records which follow show the New Yorkers far in the lead of their nearest competitors. The record of New York is 8.18 hits per minute, Maine, 6.30 hits per minute; New Jersey, 4.71 hits per minute; Rhode Is-

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land, 4.30 hits per minute; Connecticut, 3.04 hits per minute; Massachusetts, 3.04 hits per minute. The highest record for an individual gun captain was made by C. V. Purdy of the third division, fifth battalion, New York, whose score of 13.04 shots per minute is said not to have been equaled on the Atlantic coast.

During the cruise Lieuts. E. C. Sornberger and Thomas W. Harris, of the Buffalo division, with several other commissioned officers of the naval militia, made a two hours' trip under water in the submarine Octopus, of which Lieut. Charles Courtney, an expert on submarine construction and navigation, and also hailing from Buffalo, is in command. While the Octopus was submerged at a depth of about 35 ft. target practice was indulged in by the crew under the direction of Lieut. Courtney.

While the Buffalo division is a comparatively new organization, many of its members have had experience in other divisions or in the regular navy. Lieut. Sornberger is a graduate of Annapolis and an experienced commanding officer, Lieuts. Harris and Ransom and Ensigns Hesselman, Burrrows and Morse are also capable officers with considerable training. Lieut. Hesselman served with distinction in the navy during the Spanish-American war, and is one of the most popular young men in Buffalo. The practice cruise ended in New York on Saturday, Aug. 15, the Buffalo division arriving at its home port two days later, being received and escorted by the band of the 74th Regiment to its palatial quarters in Niagara street.

LAKE FREIGHT SITUATION.

There is little change to be noted in the general lake situation. While the ore movement is a trifle better the coal movement has fallen off, and all that the shippers can do is to take care of contract tonnage. The coal movement throughout the season has not been heavy. Orders from the northwest have been infrequent and the usual quantity of coal has not gone forward from upper lake ports. The result will be a congestion during the fall months or else a severe shortage during the winter.

August ore figures are not yet at hand, but as the movement of the past two weeks was not as good as during the first fortnight the total will be moderate. The bulk of the business will have to be transacted during the fall months when heavy weather and other vicissitudes incidental to the season will have to be met.

PIG IRON SITUATION.

August has proved the best month of the year so far for the iron business, but the improvement has been slow. Many of the larger manufacturers—especially the United States Steel Corporation—are continuing the making of plant improvements, and a large percentage of blast furnace owners throughout the country have either relined, or are replacing old machinery with up-to-date equipment. Pig iron sales in the east have been fair in volume, but the market generally is quiet and prices show little change. Fair sized contracts for structural material have been awarded, and there is good demand for reinforcing bars to be used in concrete construction. No rail contracts of any size have been offered, but a considerable tonnage of structural material for railroad depots, bridges, etc., has been closed. The demand for sheets has increased, as well as merchant pipe. The coke business is very dull.

HUNTSBERY CLAM-SHELL BUCKET.

Further records of importance to dock managers were made by the Huntsbery clam-shell bucket on the Cleveland & Pittsburg dock at Cleveland. The steamer Cornell reached the dock at 4 A. M. Aug. 25 and left at 9 P. M. the same day, having discharged 7,514 tons of Norrie ore. Of this amount 2,100 tons were unloaded by the Hulett bucket in 11 hours, an average of 190.9 tons per hour. The five remaining rigs worked a total of 62 hours, taking out a total of 5,414 tons, an average of 87.3 tons per hour.

On the new steamer J. J. Sullivan the Huntsbery bucket did even better on Aug. 20. The Sullivan reached the dock at 1 A. M. and left at 3:30 P. M. the same day, having discharged 10,002 tons of Anvil ore. Of this amount the Huntsbery bucket unloaded 2,184 tons, an average of 198.5 tons per hour. The exact data of the remaining rigs is not at hand.

Much interest has been manifested in the performance of this bucket by the dock companies. It possesses a great advantage in its capacity of heeling on a very small quantity of ore, and reaching to its full opening of over 18 ft. in any direction therefrom. It economizes by making possible a reduction in the force of hand shovelers.

NEW CHARTS OF ST. CLAIR RIVER AND LAKE ST. CLAIR.

The United States Lake Survey office has issued new editions of the charts of St. Clair River and Lake St. Clair. These charts are printed in five colors, The charts may be obtained from the Lake Survey office, Old Custom House, Detroit, Mich., or from the MARINE REVIEW.

The new St. Clair river chart covers the river from St. Clair Flats canal to the foot of Lake Huron, is on scale of 1.6 inches to the mile, and includes many changes from conditions shown by prior editions, particularly alterations in the aids to navigation along this important waterway. In addition, the chart has three insets on larger scale (about 4 inches to the mile), showing (1) vicinity of Algonac and Grande Pointe, (2) Marine city and vicinity, and (3) shoals in vicinity of St. Clair and Stag Island.

The new edition of Lake St. Clair, extending from Windmill Point light at head of Detroit river to beyond Algonac above St. Clair Flats, on scale of about 1¼ inches to the mile, shows heretofore uncharted shoal water along either side of the ship channel through Lake St. Clair, and recent changes in aids to navigation in Anchor Bay and vicinity of St. Clair Flats canal and ship channel. The west shore of the lake from Grossepoint waterworks to Lakeside Inn has been thoroughly revised from a recent survey made by the Lake Survey, embracing many topographic changes. New sailing courses from Grossepoint light-ship to mouth of Clinton river (where new range lights were recently established) and to New Baltimore are also given.

"TORONTO SHIPYARDS."

The old Bertram shipyard at the foot of Bathhurst street, Toronto, will resume operations under the name of "Toronto Shipyards." It is expected to put the plant in shape to undertake the building of complete vessels of all descriptions as well as to do all kinds of repair work to ships, machinery and boilers. The plant will go into operation early in September.

The barge Carrington, bound down with ore in tow of the steamer Maunaloa, broke her wheel chains at Port Huron last week and crashed 30 ft. into the new dock of the Grand Trunk railway. Caught in the rapid current, neither the steamer nor her anchors could hold her. She broke both her anchors and was herself considerably damaged. She was towed to Conneaut and later taken to Cleveland for repairs.

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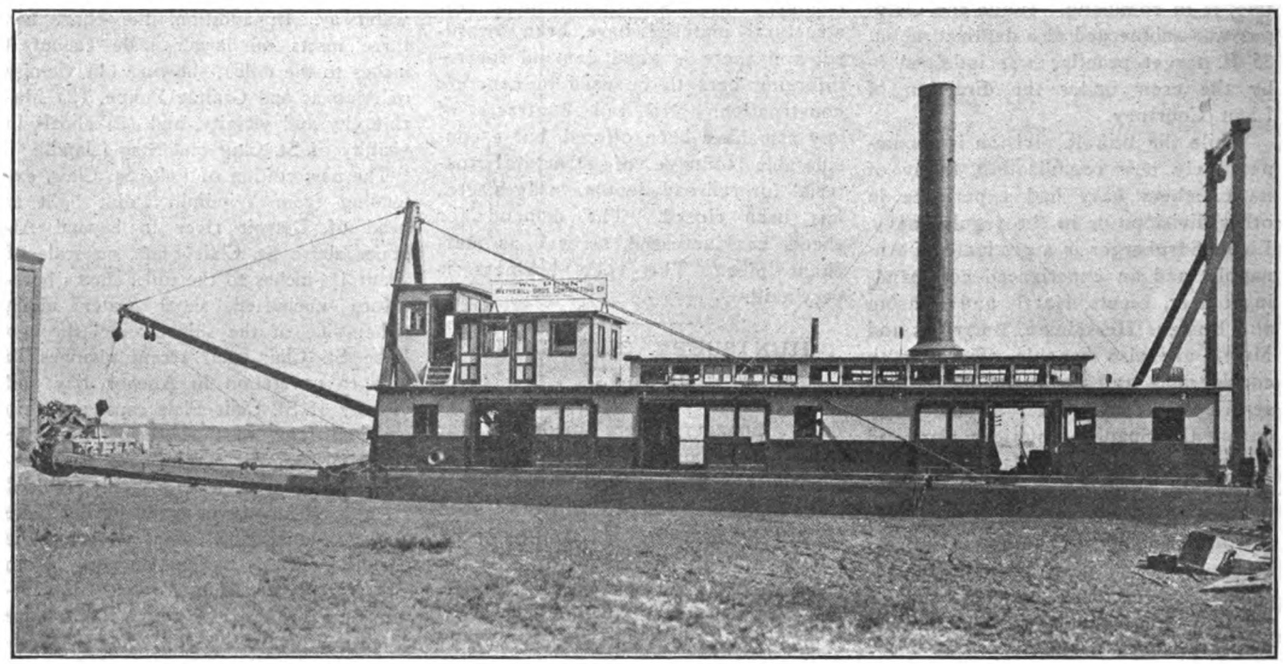
DREDGES WILLIAM PENN AND DALECARLIA.

The dredge Wm. Penn has recently been completed at the yard of the Wetherill Bros. Machine Co., Chester, Pa., for a contracting firm now engaged in government work in the Appomatox river near Petersburg, Va. The hull is 85 ft. long, 23 ft. 10 in. beam and 18 ft. deep. The dredge draws about 4 ft. of water and was designed to pass through the Delaware and Raritan canal and the Delaware and Chesapeake canal locks.

As the principal cost of dredging machinery is usually repair cost, construction throughout has been made doubly strong. The engine is compound condensing, 12 and 14 in. cylinder diameters by 14-in. stroke, directly connected to a 12-in. steam pump with an impeller 5 ft. in diameter. The capacity of the pump is from 2,000 to 2,500 cu. yds. per day and will excavate in 30 ft. of water. Steam is supplied by a Worthington water-tube boiler 200 H. P. capacity allowed 150 lbs. steam pressure. The hoisting, mooring and operating lines are operated by a six-drum hoisting engine placed in the bow and fitted with a shaft which is carried through the side of the house and winch heads placed on it for handling scows, hoisting, pulling and various other work The cutter head is a solid steel casting without any rivets or bolts whatever in its construction, and is mounted on the end of a wooden ladder formed of 12 by 16 in. timbers. This agitator is rotated by a pair of 8 by 8 double engines with machine-cut gears driving a universal joint which is attached to the shaft on the ladder. This arrangement allows the cutter head to be moved in any direction. Two 16-in. spuds are carried in cast steel pockets on the stern and these are raised with a suitable frame with lines which are attached to the hoisting engine.

The suction and discharge pipes are fitted with numerous clean-out boxes to remove any foreign material that gets into the suction pipe and cannot be expelled through the discharge pipe. These clean-out boxes are arranged with hinge bolts so that the smallest possible time is required to open the boxes and remove rocks and stumps that may lodge therein.



DREDGE WILLIAM PENN.

The dredge was furnished complete with 500 ft. of pontoon pipe and 500 ft. of land pipe. Fourteen pontoons were also furnished, 16 and 6 ft. by 2 ft., with 18 rubber sleeves. The dredge is lighted throughout by electricity as it operates both night and day. The deck house has quarters for 16 men.

The Wetherill Bros. Machine Co. also designed and built the dredge Dalecarlia for the United States government to be used in cleaning out the Dalecarlia reservoir near Cabin John bridge which crosses the Potomac a short distance beyond the District of Columbia. This natural reservoir covers 40 acres and has been used for many years in supplying the city of Washington with water. It is fed by water taken from the Potomac river about 12 miles up stream and led to it through a brick and concrete conduit. During the past years large quantities of silt have been washed down in the reservoir greatly reducing its storage capacity. It was finally determined to construct a hydraulic dredge for the work.

The Wetherill Bros. Machine Co. took the contract for building and equipping the dredge complete. As the reservoir is some five miles from a railroad station the hull had to be knocked down and reassembled on the banks of the reservoir.

The dredge has a wooden hull 66 ft. long, 24 ft. wide and 6 ft. deep. The new engine is compound, 10 and 20-in. cylinders by 10-in. stroke, direct connected to a 10-in. suction and 12-in. discharge pipe, capable of delivering 2,300 gallons of water per minute against a 60 ft. head with boiler pressure of 100 lbs. which is equivalent to 180 cu. yds. per hour of such matter.

The boiler is 150 H. P. Worthington water-tube. The main engine pump and boiler are located on the fore and aft keelsons, while on the same deck is located a five-drum hoisting engine with cylinder 6¼ by 10 in., drum 18 in. by 20 in. long. This outfit operates the spuds, ladders and shore lines. Mounted on the deck, directly in front of this hoisting engine, is placed an 8 by 8 double engine connected with machine-cut bevel and spur gears to the cover head shaft by means of a cast steel metal joint. In connection with the dredge the company furnished forty pontoons, 2 ft. by 6 ft. by 16 ft., and 1,000 ft. of 12-in. pontoon and land pipe complete with rubber sleeves.

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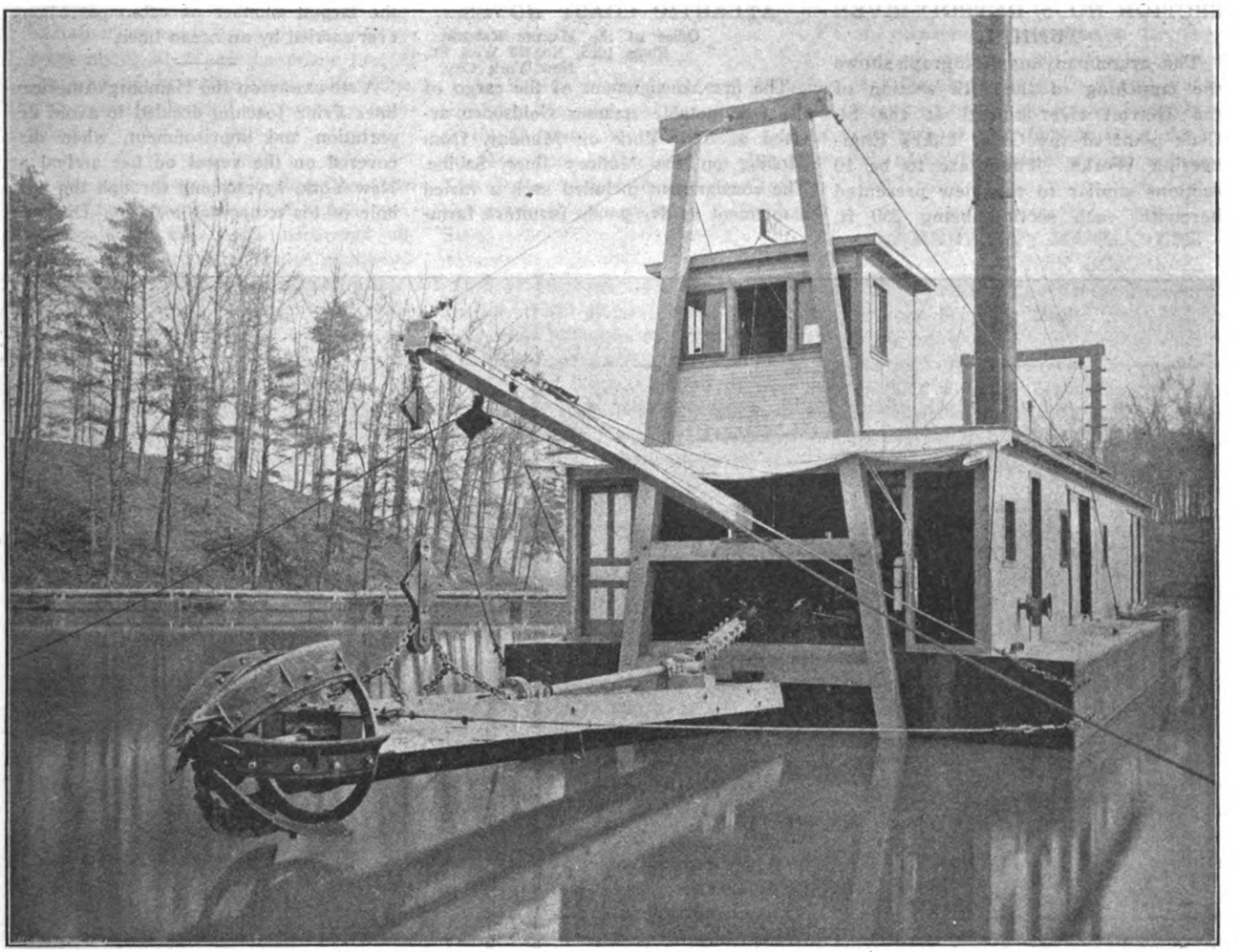

DREDGE DA LECARLIA.

BOSTON MARINE NOTES.

Boston, Sept. 2.—Twenty-four years is a long time for a ship to be away from its home port, but that is the record of a whaling barque that recently docked in New Bedford. The vessel left New Bedford in 1884 for a voyage around Cape Horn and since has been engaged most of the time in whaling in northern latitudes. The ship brings news that the whaling ships in the Atlantic are generally making heavy catches this season. The whaling business seems to have experienced a revival, and with this New Bedford is developing new importance which presents some likeness to its old-time activities as a whaling port.

The owners of the Italian barque Rosalia d'Ali, have just accepted the lowest freight rate paid in years for carrying a lumber cargo to South America. A cargo of more than 1,000,000 ft. will be taken from this port to Buenos Ayres at the rate of $6.75 per thousand. When shipping is real brisk as high as $9.50 is considered not an exorbitant rate. Recent shipments have gone forward at about $8 per thousand.

Commissioned by the Japanese government to make a special study of the different phases of the fishing industry as it presents itself to one serving aboard a fishing vessel, M. Tanaka, a nobleman and merchant of the Island Kingdom, went out August 25, on board the steam trawler Spray, bound for Georges Banks.

M. Tanaka is preparing a report to be submitted to the government on his return home and it will embrace conditions existing in the principal fishing ports along the Atlantic coast, Boston in particular, because of its ranking first place as a fish mart of this country and one of the largest in the world.

It is believed that the report will have a good deal to do with the progress of the fishing industry in Japan, a question now receiving considerable attention from the Japanese government.

Shortly after the Spray, built by the Fore River Ship Building Co., went into service two years ago, another representative of the Mikado went aboard and served as one of the crew, securing data for a report, and the results of M. Tanaka's investigation will be supplementary to the first.

At the present time coal cargoes to this port from Baltimore are bringing from 50 to 60 cents per ton freight money, from Philadelphia 50 cents, from Portsmouth 60 cents, and from Washington the rate is 50 cents.

The navy department has directed the commandant of the Mare Island navy yard to proceed with the work of overhauling the protected cruiser Raleigh, torpedo boat destroyer Paul Jones, and the gunboats Vicksburg and Petrel. The latter vessel has been out of commission for nearly four years. All the vessels will be put into commission as soon as the repairs are completed.

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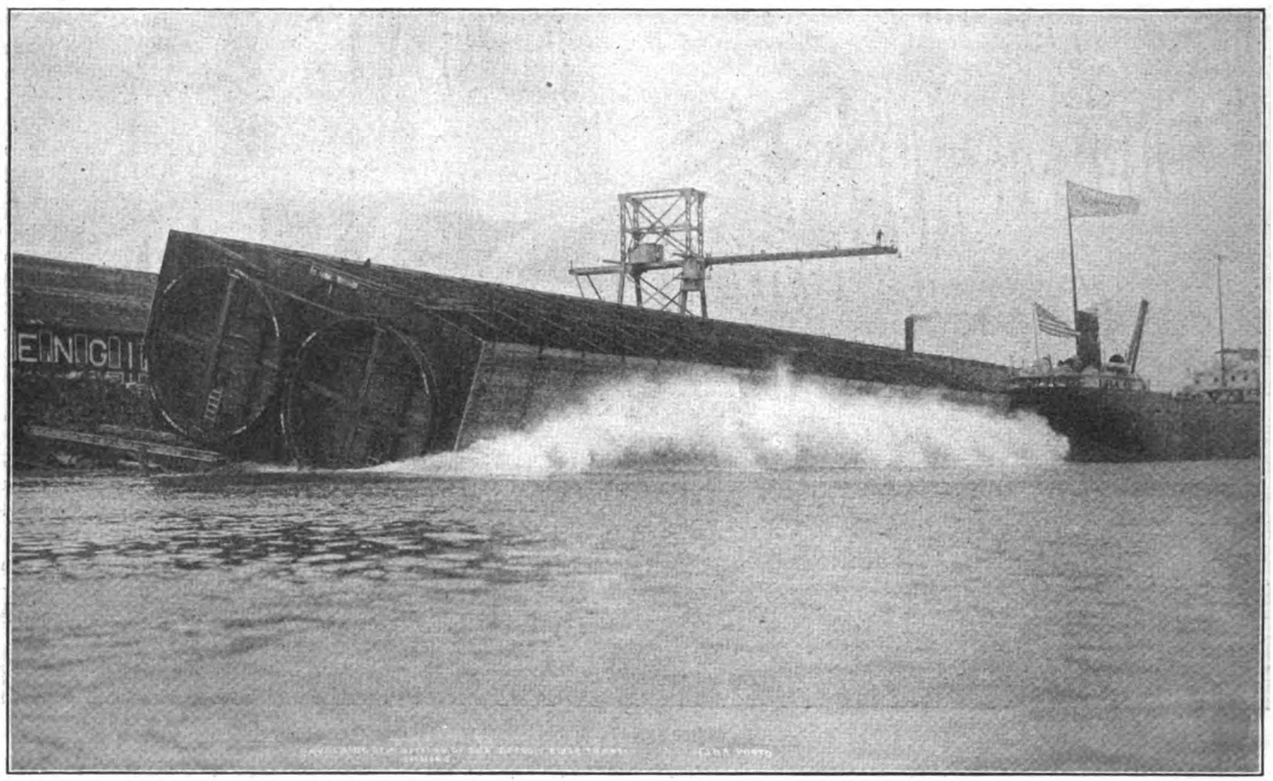
SECTION NO. 5, DETROIT RIVER TUNNEL.

The accompanying photograph shows the launching of the fifth section of the Detroit river tunnel at the St. Clair plant of the Great Lakes Engineering Works. There are to be 10 sections similar to the view presented herewith, each section being 260 ft. long, 23 ft. 4 in. diameter. These sections are to be laid on the bottom of the Detroit river and encased in cement. The subaqueous portion is 2,625 ft., but the total excavation including approaches will be 2.42 miles. This tunnel is building for the Michigan Central railroad.



LAUNCHING SECTION NO. 5 DETROIT RIVER TUNNEL AT THE ST. CLAIR YARD OF THE GREAT LAKES ENGINEERING WORKS.

The Champion Rivet Co., Cleveland, has appointed Alexander S. Mitchell, 45 Broadway, New York, to represent the company in New York City and surrounding territory for the sale of Victor boiler, ship and structural rivets. This company has the largest rivet capacity of any plant in America.

On the turbiners Yale and Harvard, between New York and Boston, charcoal filters have recently been installed and are giving the utmost satisfaction, the water used in all parts of the ships, whether for drinking, culinary or bath, being as clear as crystal.

ATLANTIC COAST NOTES.

Office of the MARINE REVIEW,
Room 1005, No. 90 West St.,
New York City.

The first consignment of the cargo of the now notable steamer Goldsboro arrived at New York on Monday, from Mobile, on the Mallory liner Sabine. The consignment included such a varied assortment as dry goods, furniture, farming implements, bric-a-brac, sewing machines, phonographs and other stuffs. The Goldsboro has a fair cargo of general merchandise and is being unloaded at Mobile for the benefit of all concerned. Bailey, head of the now defunct Export Shipping Co., who escaped with the Goldsboro from New York to Honduras, and later escaped from the officers who there arrested him, is still at large.

Fire broke out on Saturday in the hold of the White Star line steamship Baltic, at New York, being confined to one compartment and quickly subdued by the prompt work of the steamer's crew. The fire, the origin of which is unknown, was found to have started in a load of coiled rope.

The steamship Rotterdam, of the Holland-America line, arrived in New York this week with 1,014 cabin passengers, 447 of this number being first class. This is the largest number of cabin passengers ever carried by an ocean liner.

A stowaway on the Hamburg-American liner Prinz Joachim decided to avoid deportation and imprisonment, when discovered on the vessel on her arrival at New York, by escaping through the port hole of his temporary lock-up. Divested of his clothing he swam away from the vessel, only to be picked up by the police patrol boat. He was returned to the immigration officials.

Oil exports from Philadelphia for 1908, so far, have been 279,709,000 gallons, a gain over the corresponding period of last year of 8,000,000.

The steamship Parthian, of the Merchants' and Miners' line, which was damaged by fire recently, has arrived at Philadelphia from Wilmington, having been repaired at the yards of Harlan & Hollingsworth.

All customs laborers at the Port of New York are to have an advance in pay to $840 per annum.

The steamer Tudor Prince, of the Prince line, while veering to avoid colliding with a tug when outward bound for

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Hongkong with a cargo of general merchandise last week, crashed into and tore away about 20 ft. of the public pier at the foot of Bayridge avenue, Brooklyn. The vessel proceeded on her way uninjured.

The bulk-oil steamship San Christobal takes the first shipment of refined petroleum from the newly discovered oilfield in Mexico, having loaded at Minatitian for a continental port 800,000 gallons of oil.

It is interesting to note that under a contract with Great Britain, which has still 19 years to run, the Cunard Line is obliged to call at Queenstown on the outward voyage. This in regard to the report that the steamship company will abandon Queenstown as a port of call.

The steamship City of Everett has sailed from Point Breeze for London, with a barge in tow consigned to Avonmouth. The barge, S. O. No. 94, carries 2,100,000 gallons of oil, and the City of Everett 1,200,000 gallons. Both vessels are bulk oil carriers and are equipped with wireless telegraphic outfits.

At recent meetings of the representatives of the chief Italian steamship companies, held in Rome, it was decided to establish special lines at the ports of Northern Europe to compete with the larger steamship companies in the emigrant trade.

The Norwegian steamship Beacon, under charter to the Atlantic Fruit Company, went ashore on Thursday off Port Maria, on the north side of the island, during a heavy norther. She floated a day later and, having shown herself seaworthy under survey proceeded for Baltimore.

The United States battleship Idaho, at League Island navy yard, will be the first vessel to have her coat of paint changed from a white to a slate color in accord with the recent order of President Roosevelt that all battleships and cruisers are to undergo the change.

"Oh, Captain, is that a wireless message you just received?"

"Yes, a fellow brought it in a boat." *N .Y. Telegram.*

Bids for a renewal of the contract, which runs for three years, for feeding the immigrants on Ellis Island, were to have been opened on July 27. They were declared off, however, and the official excuse is said to be that the contracts were thrown out because the department wanted a more scientific menu for incoming aliens. There are several unofficial excuses.

The British steamship Queen Adelaide, which has been anchored for three months in the Delaware river, has been sold to the New York Lubricating Oil Company The Queen Adelaide hails from Glasgow, her managing owners being T. Dunlop & Sons.

The French liner La Gascogne reported on her arrival at New York, having encountered 24 hours of terrific weather. One passenger was slightly injured.

The conference held at London of the leading steamship companies engaged in the North Atlantic trade, terminated with the satisfactory settlement of many points of discussion. The only new arrangement of general public interest is the inclusion of the Russian line from Libau to New York in the North Atlantic pool. Only the British and northern continental companies were represented, the conference being in no way connected with the Mediterranean service.

The Sound steamer New Hampshire, of the Norwich line, during the dense fog of Tuesday morning, collided with J. Pierpont Morgan's yacht, the Corsair, in the East River, New York. The Corsair was lying at anchor in the river when the New Hampshire, which was proceeding at reduced speed and had stopped her engines immediately preceding the accident, drifted into the yacht. The steel bowsprit of the Corsair penetrated the superstructure of the New Hampshire, tearing out the walls of ten staterooms and doing other damage. The bowsprit and upper deckhouse of the yacht were carried away and the foremast was snapped off flush with the deck. The steamer Priscilla, which has come up astern of the New Hampshire, assisted in getting the vessels apart. The Corsair later was taken to the yard of W. & A. Fletcher, Hoboken, for repairs.

The long passage of the bark Good News, from Philadelphia for Tacoma, was due to severe weather and the loss of the vessel's foremast and yards. New sails had to be cut and bent and a jury rig fixed. The Good News had a crew of thirteen men, and the passage lasted 209 days.

John H. Starin, of New York, recently celebrated his eighty-third birthday.

If the no-tip system really comes into force on the Atlantic it will at least dispense with the necessity of tipping certain individuals who were of absolutely no service during the trip. We have in mind an individual who approached us on one occasion, just previous to the vessel's docking, with the information that he was the ship's "boots." As we till that moment had had no reason to credit the existence of such individual on the vessel, naturally enough we did not again "dig."

AMERICAN MANGANESE BRONZE CO.

The American Manganese Bronze Co., 99 John St., New York, U. T. Hungerford, president, W. A. Locke, secretary and treasurer, announce the completion of their works at Holmesburg Junction, Philadelphia, on the New York division of the Pennsylvania railroad. The buildings are of reinforced concrete and steel framework construction, with brick curtain walls, and consist of melting plant and foundry, metal storehouse, core shop and office, with complete chemical and testing laboratories, light and power plant and machine shop.

The main building is equipped with a 10-ton Niles electric traveling crane, which together with a one-ton electric hoist serves the entire plant. Special attention has been given to light and ventilation. The plant is equipped with pneumatic tools for the cleaning of castings and its 600 ft. of siding running the entire length of the plant insures economical handling of raw materials and shipments.

Nothing has been omitted in the construction of this plant that would tend to make it thoroughly modern and up to date in every particular.

The products of the American Manganese Bronze Co. comprise ingots, billets, forgings, rods and sheets, together with both large and small castings, their facilities permitting them to supply bronze castings up to 20,000 lbs. each and in this particular they occupy the unique position of being able to produce the largest bronze castings in this country. In addition to their special Spare's Manganese Bronze, Spare's White Bronze and Spare's Hydraulic Bronze alloys, they also produce standard United States government compositions and other high grade alloys designed to meet the most severe engineering requirements.

The government of New Zealand has refused to enter into any agreement to subsidize the Canadian-Australian line on the ground that owing to the call of the company's steamers at Brisbane the service is of no value to New Zealand. The Canadian government has recently refused the same company a renewal of its subsidy under the increase asked for with an offer to improve the service.

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THE JETTY AND PORT WORKS OF RIO GRANDE DO SUL, BRAZIL.

The bar across the channel connecting the harbor of Rio Grande do Sul and the Lagoa dos Patos, an immense body of water about 200 miles long and 20 to 30 miles wide, with the sea has effectually prevented the free movement of commerce of a state of 1,400,000 inhabitants, and has been the cause of much discussion in Brazil. Besides Rio Grande do Sul, a city of 45,000 people, there are two other large cities on or near the Lagoa dos Patos; the first, Pelotas, a place as large as Rio Grande do Sul, and the other, Porto Alegre, a city of over 75,000 inhabitants. The active development of the port and the construction of the jetties have now been undertaken under the direction of Dr. E. L. Corthell, from whose description of the project in the Engineering Supplement of *The Times*, London, the following notes have been condensed by the *Engineering Record*:

Within the bar, for many miles, is one of the best of harbors, with a minimum depth of 36 ft., and a channel of very considerable width. Near this harbor, and connected with it by a dredged channel 15 ft. deep, is Rio Grande do Sul. The Lagoa dos Patos for 100 miles is 30 ft. deep, and connected to this deep water by a 12-ft. dredged channel is Pelotas. Porto Alegre is situated near the farther end of the Logoa and is approached by shallow and tortuous channels which are now being dredged to a depth of 10 ft.

The drainage waters of the Lagoa come from an area of 63,000 square miles and entering at various points unite in one great volume in Canal do Norte, and then pass out to the sea. As the waters issue from the shore line they spread out fan-like over a bar, on which there is a minimum depth of 11 ft. to 18 ft., as ascertained by the annual surveys made every year since 1883. The bar is composed of sand with a slight admixture of clay. Like the bars at the mouths of other large rivers, the channel can be deepened by extending artificially the natural banks of the river out over the bar into the deep water of the sea. The river mouth does not have a delta—it enters the sea in one solid volume with no subsidiary channels. It concentrates the drainage of a great area and sends it out to sea through this one opening, the discharged waters being comparatively clear, the sediments brought down by the rivers having been deposited in the Lagoa at points far distant from the bar.

The mean tidal range is about 2 ft., and the extreme range is about 8 ft., largely due to the winds. The currents of Canal do Norte and of the ocean have been carefully measured—the latter averages about one mile per hour, flowing southerly along the coast, and the former varies with the drainage conditions, which depend upon the rainfall of about 46 in. per annum, and the winds which raise and lower the water surfaces, the current varying from two to four miles per hour. The discharge of the waters from the Canal do Norte, due to the fluvial volume passing to the sea, averages about 175,000 cu. ft. per second for the whole year—250,000 is not uncommon, and 500,000 may be considered a maximum—equal to one-half the flood discharge of the Mississippi river at its mouth. Inside the bar at Canal do Norte is a deep and wide channel 14 miles long with a 33-ft. channel three-quarters of a mile wide. This splendid channel proves the existence of strong persistent currents which may be utilized to deepen the channel through the sea bar to the depths existing in the Canal do Norte.

The hydraulic, and, in fact, all the physical conditions, are very favorable for the projected improvements, which consist mainly of two parallel dikes or jetties, extending from the seashore at the mouth of the river out over the bar to a depth of about 31 ft. in the sea. The width between these jetties over the bar will be about 2,460 ft., somewhat less than the width of the hydraulic channel inside the shore lines. They will be built of random stone rubble, with the slopes well protected with large stones weighing from 5 to 10 tons, and the most exposed parts with stone or concrete blocks of 20 tons weight. The central part of the dikes will be composed of small stone and quarry refuse to make them less permeable to the flow of water through them. Where necessary, willow fascine mattresses will form the base of the dikes. The dikes will be well above high water and the height will be increased as they go seaward, the grade running up from the shore to the sea ends, where, on a broad and stable base, will be erected light towers to mark the channel entrance from the sea.

In order to construct the dikes with rapidity, which is one of the essentials in such works, a double-track railroad will extend out from the shore for transporting the stone to the advancing sea ends, where the 25-ton loaded cars will be lifted bodily by a 50-ton Titan or Goliath crane, and stone will be dumped from the cars into the sea in advance of the dike or onto its slopes. When it is known that at times from 3,000 to 4,000 tons of stone must be deposited daily, it will be understood why special plant and extraordinary facilities must be provided. The entire work will require nearly 3,000,000 tons. The stone will come from quarries located about 50 miles from the works, and a special railroad of standard gage (4 ft. 8½ in.) will be built from the bar to Monte Bonito, about 12 miles north of Pelotas. This railroad will have a 75-lb. rail and will be equipped with powerful locomotives and a large number of stone cars, so that the trains can move constantly day and night between the quarries and the works.

The stone for the east jetty, which is the longer of the two and the more exposed to waves, will be transferred across the Canal do Norte on a car ferry, and the stone will be deposited as above described.

There are some auxiliary works contemplated, such as the completion of the protection of the west bank of Canal do Norte begun by the government, consisting of willow mattress work loaded with rubble stone, and the planting of salt tamarack on the sandy point on the east side to stop the blowing of the sands. The government has already done nearly all the necessary work of this kind. There may possibly be some dredging on the bar to hasten the development of the channel. As already stated, the volume of water available for the deepening of the channel is very great, and the currents to be created on the bar by the works of concentration will easily excavate and carry to far distant points in the sea the sands composing the bar.

One important factor in the operation of the works is the existence of the littoral, or shore currents. These currents in the normal condition of the bar have been sufficient to retard its advance in deep water. The works will increase their velocity, and they will sweep away the sands which might otherwise be deposited in front of the works. They will continually act as a planer to shave off the otherwise protruding bar, exactly as they have done during the last 12 years at the mouth of the Panuco river at Tampico, Mex., where Dr. Corthell

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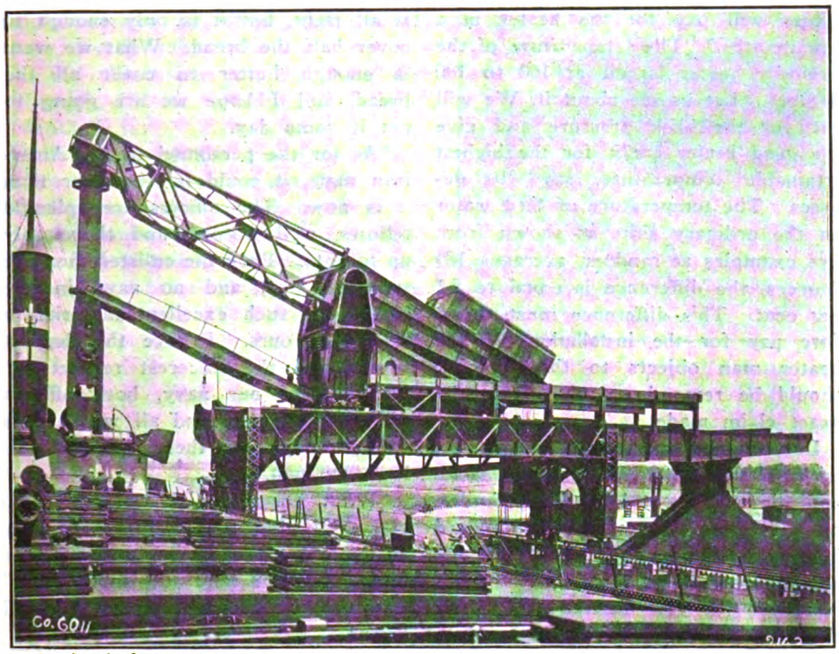
designed and built similar works under more difficult physical conditions, and where a channel over 28 ft. deep (24 ft. being the maximum required) has been maintained since 1893 without any artificial means, and where there is now more and deeper water in front of the works than in 1889 when the preliminary surveys were made for the works on this stormy shifting bar with only 8½ ft. of water



dredged from the channel area, will be installed electric cranes from 2½ tons capacity to 30 tons, railway tracks, electric capstans, warehouses, a cold storage plant, a corral for shipping catle, a coal deposit operated by electricity, deposit for inflammables, and all other appurtenances required for the rapid and economical handling of cargoes, as well as the warehousing and exporting the varied products of the country brought down to the port by rail and water, and the varied imports, foreign and coastwise, needed by the large population.

The construction was begun last December, and since that date the preliminary work of getting out and transporting the stone from the quarry in the Lagoa, building a railway embankment from the shore end of the west dike towards the quarry at Monte Bonito, and other necessary engineering and construction work have gone forward. There are excellent materials available for the works—a heavy porphyritic, good, sharp sand, and plenty of good willows for mattress work for the port dike work, revetment, bank protection and sea dikes. Good labor is cheap and abundant. The climate is such that work can be prosecuted during the entire year. A day's work in such a climate amounts to more than it does in some climates where the heat is overpowering and the humidity depressing.

The jetty work will cost the Brazilian government $10,125,000, which is to be paid in installments, as the

GENERAL DESIGN.

warrant officers, £120 a year; a number of midshipmen, or naval cadets; a sick-bay staff, carpenters and artisans, cooks and domestics, bandsmen and ship's police, besides all the petty officers, seamen, boys, engine-room artificers and stokers. She carries also marines, both artillery and light infantry. So it is not wonderful that the total pay roll exceeds £40,000 a year.

The cost of victualing varies very greatly in different places. In some places you can buy beef as cheaply as 3d a pound; in others—such as Ascension—it costs 2s 6d a pound. The men nowadays get five meals a day, if you include the early morning cocoa. Until lately they had three only. In round figures the feeding of a Dreadnought's crew costs £18,000 a year. Coal is, of course, an item which depends upon the distance traveled and the speed. Although the Dreadnought's turbines can drive her through the water at 24 miles an hour, she usually travels at an economical cruising speed of about ten knots. Even so, the 2,700 tons of best Welsh which her vast bunkers contain will carry her only 5,800 sea miles. Besides the vast amount which she uses for steaming, she needs coal for distilling, for making electric light and for the pumping and other auxiliary engines, of which she has no fewer than 364 aboard her. The coal costs about a pound a ton and the bill for fuel—coal and oil together—comes to about the same as that for victualing. The value of the stores carried by a ship like the Dreadnought is about £120,000. Stores include paint, rope, lubricating oil, boats, tools, forges, etc. The amount used yearly would average about £7,000.

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ests which have built the Atlanta, Birmingham & Atlantic railroad and which now have control of the Wolvin Steamship Co., the Brunswick Steamship Co., and the Mexican-American Steamship Co., is to commence the operation of a freight and passenger service between New York and New Orleans about Nov. 1. This is in addition to the service maintained by this company to Texas City and places it in direct competition with the Southern Pacific Co.'s Morgan line steamers, which have hitherto enjoyed the greater portion of such traffic. The Texas City service is now in successful operation and promises to control a large portion of the commerce of the Gulf of Mexico.

A new 8,600-ton ship for the Indian service of the Anchor line was launched recently at the Henderson yards at Meadowside, England. She was named the Elysia. The new vessel, which will ply in the company's service between Glasgow and Bombay, is 440 ft. long, 53 ft.

On July 31 the navy department issued circulars inviting proposals for three new colliers authorized by the last naval appropriations act. The specifications are the same as in the former circular sent out some weeks ago, the bids for which were all rejected. Under the later circular the bids are to be opened Sept. 1. At the same time bids will be opened for the construction of the 10 torpedo boat destroyers authorized by the last naval appropriations act. As the law provides that not more than three of these vessels shall be built by any one firm it is expected that there will be a large number of bids.

The passenger steamer City of Muskegon, formerly the steamer Peerless, is being converted into a lumber carrier. The steamer was sold some time ago by the Muskegon-Chicago Navigation Co. to Capt. Louis Larsen, of Muskegon. The Peerless was formerly engaged in the Lake Superior passenger trade and was built for the firm of Leopold & Austrian.

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BUFFALO DREDGING CO.'S DRILL BOAT NO. 5.

The all-steel drill boat designed and built for the Buffalo Dredging Co. by the Empire Ship Building Co., of Buffalo, was given a crew and put in operation in Niagara River near the foot of Lake Erie three weeks ago. It has attracted a good deal of attention in marine circles and has proved a decided success. Her length is 140

Brazil. Besides Rio Grande do Sul, a city of 45,000 people, there are two other large cities on or near the Lagoa dos Patos; the first, Pelotas, a place as large as Rio Grande do Sul, and the other, Porto Alegre, a city of over 75,000 inhabitants. The active development of the port and the construction of the jetties have now been undertaken under the direction of Dr. E. L. Corthell, from whose description of the project in the Engineering Supplement of *The Times*, London, the following notes have been condensed by the *Engineering Record*:

Within the bar, for many miles, is one of the best of harbors, with a minimum depth of 36 ft., and a channel of very considerable width. Near this harbor, and connected with it by a dredged channel 15 ft. deep, is Rio Grande do Sul. The Lagoa dos Patos for 100 miles is 30 ft. deep, and connected to this deep water by a 12-ft. dredged channel is Pelotas. Porto Alegre is situated near the

and these are operated by independent engines.

This drill boat, which is designated as the Buffalo Dredging Co.'s drill boat No. 5, is a model of convenience and simplicity and a creditable piece of workmanship. The interior is equipped with a steam hammer, trolley for conveying material the full length of the boat, a complete blacksmith shop at one side, and gas supply tank at the other. The boat is lighted by gas throughout and operates day and night. She has marine fire-box boiler pumps and pumping engine 12 x 7 x 12. Nothing was omitted in designing and constructing this boat to make her admirably fitted for drill work.

SHIP YARD NOTES.

The Akers emergency steam steerer will be installed upon the two new boats which the Great Lakes Engineering Works will build for Boland & Cornelius of Buffalo.

The steamer Neepawah went ashore at Otter Head near Michipicoten with a cargo of package freight. The steamer Wahcondah was sent to release her. She was released with great difficulty and towed to the Ecorse plant of the Great Lakes Engineering Works for repairs.

General Manager B. W. Parker, of the White Star line, announces that plans for a new passenger steamer are practically complete and that they will be submitted to the shipbuilder

upon the rainfall of about 46 in. per annum, and the winds which raise and lower the water surfaces, the current varying from two to four miles per hour. The discharge of the waters from the Canal do Norte, due to the fluvial volume passing to the sea, averages about 175,000 cu. ft. per second for the whole year—250,000 is not uncommon, and 500,000 may be considered a maximum—equal to one-half the flood discharge of the Mississippi river at its mouth. Inside the bar at Canal do Norte is a deep and wide channel 14 miles long with a 33-ft. channel three-quarters of a mile wide. This splendid channel proves the existence of strong persistent currents which may be utilized to deepen the channel through the sea bar to the depths existing in the Canal do Norte.

The hydraulic, and, in fact, all the physical conditions, are very favorable for the projected improvements, which consist mainly of two parallel dikes or jetties

The experiments with the Lyle gun aboard the vessels of the Pittsburg Steamship Co.'s fleet are very satisfactory. The barge Corliss was picked up off Fairport by means of the gun at a distance of from 300 to 400 ft.

The lighthouse tender Anemone has reached Detroit from the yard of the New York Ship Building Co., Camden, N. J.

The steamer Iron King with the barge Iron Queen in tow parted a tow line abreast of Amherstburg last week. She was released without injury after several tugs had pulled on her.

Hugo & Tims, Duluth, have been awarded contract for building the new life saving station at Harbor Beach, Minn., at $50,000.

Capt. John Green of the steamer Wisconsin has been appointed shipping master for the Lake Carriers' Association at Milwaukee.

The Barnett & Record Co. have been given the contract by the Consolidated Elevator Co. to build a new grain elevator on the site of the burned elevator D on Rice's Point. The new elevator will have a storage capacity of 1,400,000 bu. It will be constructed of concrete and tile and will be strictly fireproof. The contract calls for completion by Aug. 1, 1909.

The Detroit Ship Building Co. last week concluded repairs on the car ferry St. Marie, including the putting in of 16 new furnaces.

The steamer Montana is at the yard of the Great Lakes Engineering Works

must be provided. The entire work will require nearly 3,000,000 tons. The stone will come from quarries located about 50 miles from the works, and a special railroad of standard gage (4 ft. 8½ in.) will be built from the bar to Monte Bonito, about 12 miles north of Pelotas. This railroad will have a 75-lb. rail and will be equipped with powerful locomotives and a large number of stone cars, so that the trains can move constantly day and night between the quarries and the works.

The stone for the east jetty, which is the longer of the two and the more exposed to waves, will be transferred across the Canal do Norte on a car ferry, and the stone will be deposited as above described.

There are some auxiliary works contemplated, such as the completion of the protection of the west bank of Canal do Norte begun by the government, consisting of willow mattress work loaded with

for any trade.

The barge Baldwin en route to Sturgeon Bay with stone turned turtle off Twin River Point in a blow last week.

OBITUARY.

Regret is universally expressed over the untimely death of Wm. S. Huff, chief engineer of the Detroit & Cleveland line steamer City of Detroit. Mr. Huff has been with the Detroit & Cleveland line for the past 16 years and had served on a number of vessels of the fleet. His foot was accidentally crushed by a truck about two months ago. Gangrene set in and it became necessary to amputate the foot.

Capt. Wm. H. Armstrong died at Tonawanda last week at the age of 54 years. He had sailed the lakes since boyhood. He was the president of the Strong Transportation Co., owning two steamers and a barge.

Capt. Wm. Roach died at Detroit last week. He had sailed the lakes since boyhood, his latest vessel being the steamer L. L. Barth of the Hines Lumber Co.'s fleet.

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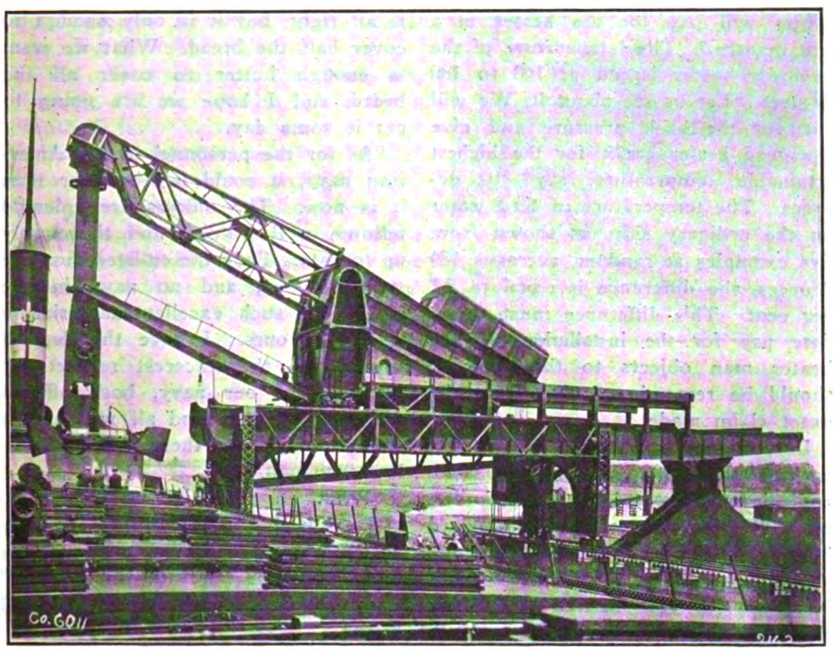
HULETT UNLOADERS AT ASHTABULA.

The Wellman-Seaver-Morgan Co. has received a contract to install four Hulett unloading machines on the Lake Shore side of the harbor at Ashtabula. The accompanying photograph shows a machine that in its general construction and outline is the same as those that will be installed on the Ashtabula docks. The



THE NEW HULETT MACHINES AT ASHTABULA WILL FOLLOW THIS GENERAL DESIGN.

Ashtabula machines, however, will have a capacity greater by 50 per cent than the one here shown. The ordinary Hulett unloader is a 10-ton machine but these new machines will be of 15 tons capacity. They are about 50 per cent heavier than the ordinary type of Hulett unloader. It is expected that each one of these four new machines will have a capacity for unloading 700,000 tons of ore in a vessel season. They will be equipped with weighing hoppers so that the ore can be weighed as it is loaded into cars. In conjunction with the machines there will be erected a storage bridge covering the dock for storing ore. The general features of the Hulett unloader are well known, but a detailed article concerning these new machines will be published later.

The Russian admiralty has decided in favor of the plans of a German firm of designers for the new battleships of the Dreadnought type, but the vessels are to be built in the St. Petersburg yards by Russian workmen with Russian materials.

CONSERVATION LEAGUE OF AMERICA.

A new organization has recently been formed through the initiative of the National Rivers and Harbors Congress, the purpose of which is to develop and preserve the natural resources of the nation. It is to be known as the Conservation League of America and has the hearty approval of President Roosevelt, who is its honorary president, as well as that of William H. Taft and William Jennings Bryan, both of whom are honorary vice presidents of the league. The active president of the new organization is Walter L. Fisher, of Chicago, and its members will be the great organizations which are especially interested in conservation.

The statement of principles of the Conservation League of America recites:

"Whereas, It is of the utmost importance that the natural resources of the nation shall be comprehensively and vigorously developed and utilized for the promotion of the public welfare without waste, destruction or needless impairment, and subject always to their intelligent conservation and the effective preservation of the rights and interests of the future generations of our people,

"Now, therefore, to secure the recognition and support of these principles by the people and by their representatives, we hereby unite in a National Conservation League and adopt for ourselves the essential parts of the declaration unanimously adopted by the conference of governors convened by the president of the United States in the White House at Washington on May 13, 14 and 15, 1908."

NEW SERVICE TO NEW ORLEANS.

The Texas City Steamship line, which is backed by the same interests which have built the Atlanta, Birmingham & Atlantic railroad and which now have control of the Wolvin Steamship Co., the Brunswick Steamship Co., and the Mexican-American Steamship Co., is to commence the operation of a freight and passenger service between New York and New Orleans about Nov. 1. This is in addition to the service maintained by this company to Texas City and places it in direct competition with the Southern Pacific Co.'s Morgan line steamers, which have hitherto enjoyed the greater portion of such traffic. The Texas City service is now in successful operation and promises to control a large portion of the commerce of the Gulf of Mexico.

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The cruiser Colorado went ashore upon Lip Lip Point, Puget Sound, Aug. 15. She was released a few hours later and proceeded to the navy yard at Bremerton under her own steam. Contrary to expectations the vessel was found to have sustained considerable damage, requiring several weeks to repair. Little damage was done on the port side but the plates on the starboard side for a distance of about 100 ft. from the bow are badly dented, and the rivets sprung. At least eight plates will have to be removed.

The Cunard line steamer Etruria was in collision with a mud scow in the Mersey, at Liverpool, Aug. 26, and was unable on account of the accident to sail for New York on that date. Her place was filled by the Umbria.

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FEED WATER HEATING.

Editor MARINE REVIEW:—The trade notice on the above subject in the REVIEW of Aug. 6, while fairly correct as to the general question, contains some statements so absolutely without foundation that they should not be allowed to pass. I quote: "On the Atlantic and Pacific oceans the feed water heater is in general use. The same may be said of our coasting trade. On the lakes, however, the vessels in this respect are neither up to date nor economic, though in the future the modern feed water heater will undoubtedly be installed as part of the equipment of the vessels in the lake trade."

This statement is unqualifiedly untrue. It does not contain one assertion which is even an approximation to the truth. It is evidently born of the dense ignorance of the manufacturer of the heater referred to of the actual conditions on the lakes and of the assumption so common in the east that the shipping of the great lakes is a joke. The lack of actual knowledge of lake ships and shipping is beyond belief. There has not been a steamer of any consequence (I think it would be perfectly safe to omit the qualification) built on the great lakes in 15 years or over without a feed heater.

As to the comparative values or efficiencies of types, that is a subject which is not to be disposed of by the statements or claims of any concern with something to sell. It has been stated before, and it is here repeated, that the fuel economy of the ships of the great lakes is not surpassed anywhere with fuels of equal value. It certainly is not in the American marine. The fuel performances of coast ships are just as well known to the builders and owners of the great lakes as at home, and the less said on the subject the better. There are more ships at sea without feed heaters than on the lakes, even in the beggarly fleet afloat there. The builders of the lakes turn out each year, in ships of over 1,000 tons, over seven times the tonnage of all the rest of the United States, exclusive of naval work, of course, and nearly 75 per cent of the total merchant steam tonnage of all classes, and the "small economies" are watched with a keenness totally unknown in coastwise business.

Various types of heaters are in use, just as there are on the coast, and all with their advocates. The value of back-pressure in raising temperature is no new discovery; it is well known and understood and just as applicable to one type as another, but brings in its train a long line of disadvantages which are positive and not worth incurring for the slight difference in economy. We long ago abandoned that practice and confine ourselves to approaching as nearly as possible the temperature obtainable at atmospheric pressure. Neither do we care to reopen the discussion.

The statement is made that "the savings from the use of a *good* feed heater will pay for the heater in a few months." The temperature of the ordinary heater is put at 160 to 180 degrees. Let us see about it. We will cut out the back pressure and give the *good* heater credit for the highest attainable temperature, say 210 degrees. The temperature of feed water on the ordinary ship, as shown from five examples at random, averages 189 degrees, the difference is equal to 2.1 per cent. This difference must therefore pay for the installation. If the heater man objects to this view it should be remembered that it is the exact claim made.

Let us take an average cargo ship with about 2,000 H. P., indicated, equivalent to about 1,000 H. P., boiler, on which heaters are rated. Standard heaters, including the one under discussion, cost about $1 per horsepower, installed. A few figures will show that with coal at $3, 2.1 per cent is the saving on 15,873 tons of coal, or about three full seasons' business. This is not, possibly, what was meant, but that is what is said. Feed water heating is good business and there is no need for making it appear ridiculous, but we cannot allow that lack of information justifies such bald misstatements as to the shipping of the great lakes, practically the only merchant marine the country has. The shipping of other countries, with which our coast harbors are filled, does not enter into the subject at all. The heater man has made an unfortunate presentation of his case to the owners of the lakes. CHIEF ENGINEER.

Buffalo, Aug. 10, 1908.

ADMIRAL EVANS ON THE NAVY.

In a recent interview at Lake Mohonk, N. Y., Rear Admiral Evans, who has just been placed upon the retired list for age, is quoted as saying that the American navy is not large enough.

"What do you think of the navy as it is today?" was asked of Admiral Evans.

"The navy is all right, but there is not enough of it," answered the admiral. "What we need is 48 first-class battleships, and when we get them I will be satisfied. We want two great fleets of 24 battleships each, one of those fleets to be on duty in the Atlantic and the other in the Pacific, 16 of the battleships in each fleet being in commission all the time, and the other eight in reserve. The navy is like the bread-and-butter story. There is plenty of bread, but not enough butter. The butter we have is all right, but it is only enough to cover half the bread. What we want is enough butter to cover all the bread, and I hope we are going to get it some day.

"As for the personnel of the American navy, it could not be finer than it is now. The officers are splendid fellows, well trained, and thoroughly up to date. Then the enlisted men are splendid men, and no navy in the world has such excellent material in it as has ours. I have the deepest regard and the sincerest respect for the men of our navy, both officers and enlisted men, and all we need is enough ships for these splendid fellows to man."

"What about aerial warfare? Do you think that the airship is to play an important part in the battles of the future, both on land and on the sea?" was another question put to Admiral Evans.

"For the present, at least, I do not think the airship is a menace so far as the navy is concerned," answered Admiral Evans. "But there is no telling what will happen. It would be foolish in this day and time to say what will or won't happen in the next 20 years. We have only to contemplate the achievements of the last 20 years to appreciate this."

Speaking of the type of battleships that are to be the marine engines of warfare in the future, Admiral Evans said he believed that the nations would continue to follow the Dreadnought type of all big gun ships, and that the ships would be enlarged until the 25,000-ton displacement figure was reached. He thinks that the 25,000-ton will be the limit, as ships bigger than that, he said, would be unwieldy and too hard to handle with dexterity.

The figures compiled by the Bureau of Immigration for the month of July show a decrease in immigration from all countries amounting to 72 per cent. For the six months ended with July 31 the percentage of decrease is 75 per cent as compared with 1907.

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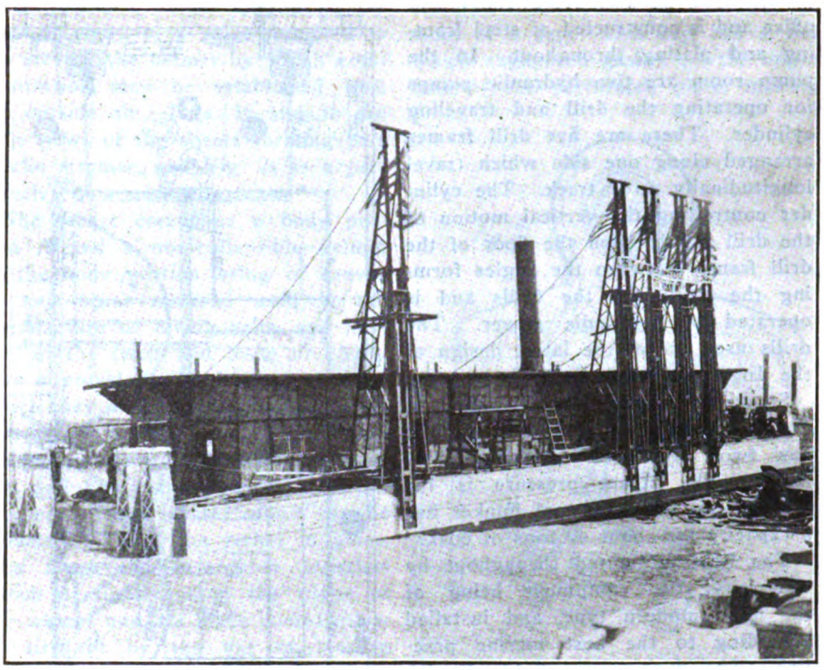
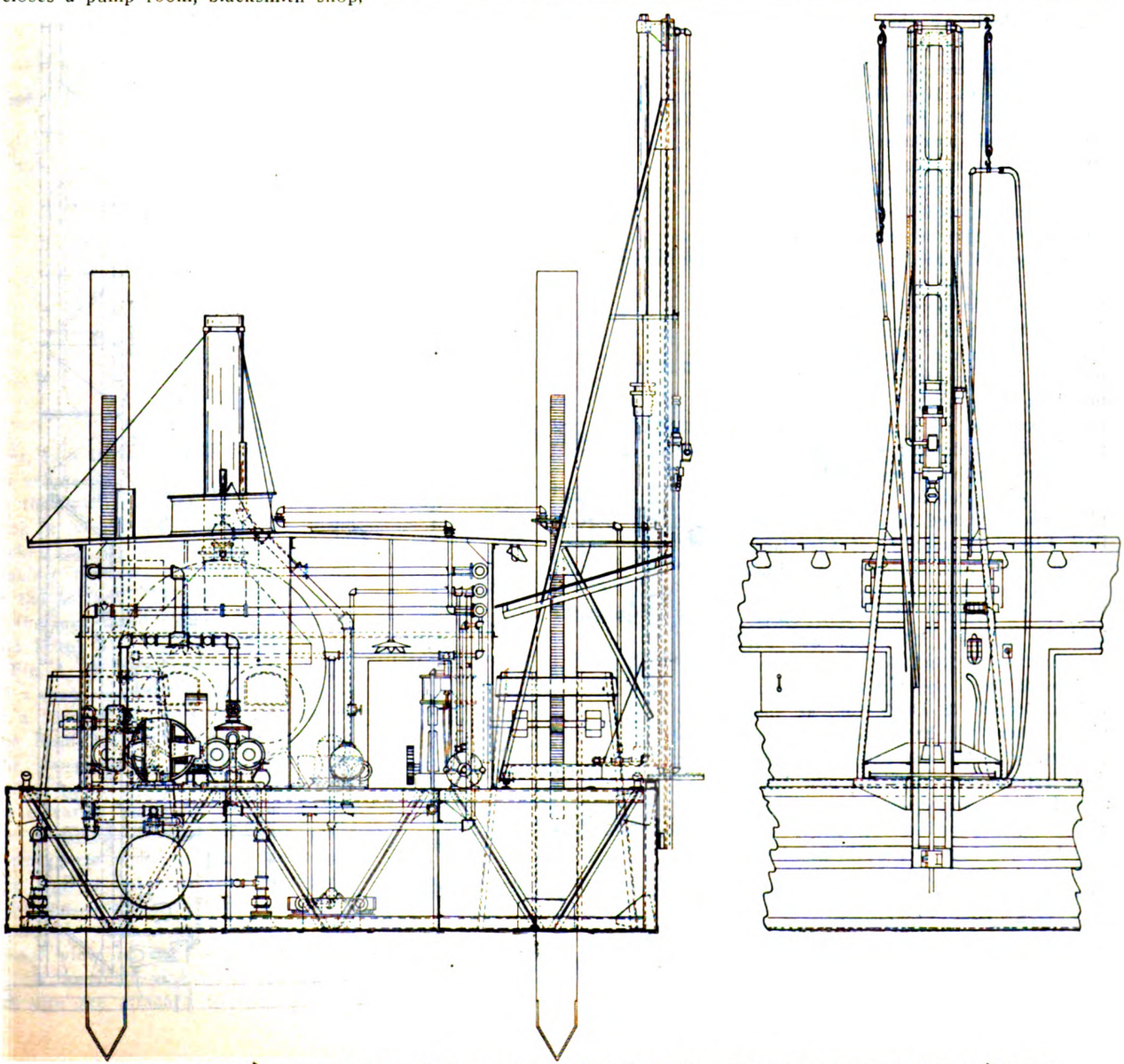
GREAT LAKES DREDGE & DOCK CO.'S NEW DRILL BOAT.

The Great Lakes Dredge & Dock Co. has just recently completed at its Cleveland yard, Drill Boat No. 4, designed for work in the new Livingstone channel at the mouth of the Detroit river. This is the first drill boat to be completed on the great lakes which is built entirely of steel. It is of especially substantial construction in all parts with a view to withstand the long and continuous hard service to which such vessels are usually subjected.

The dimensions of the boat are: Length, 132 ft.; breadth, 32 ft. 8 in.; depth, 7 ft.

The hull of the vessel is divided into five separate water-tight compartments, with communications to these from the deck only, so that the vessel is practically unsinkable by any probable damage which she might receive in service. The deck house encloses a pump room, blacksmith shop,





LAUNCHING PHOTOGRAPH AND SECTIONAL VIEW OF DRILL BOAT NO. 4 OF THE GREAT LAKES DREDGE & DOCK CO.'S FLEET.

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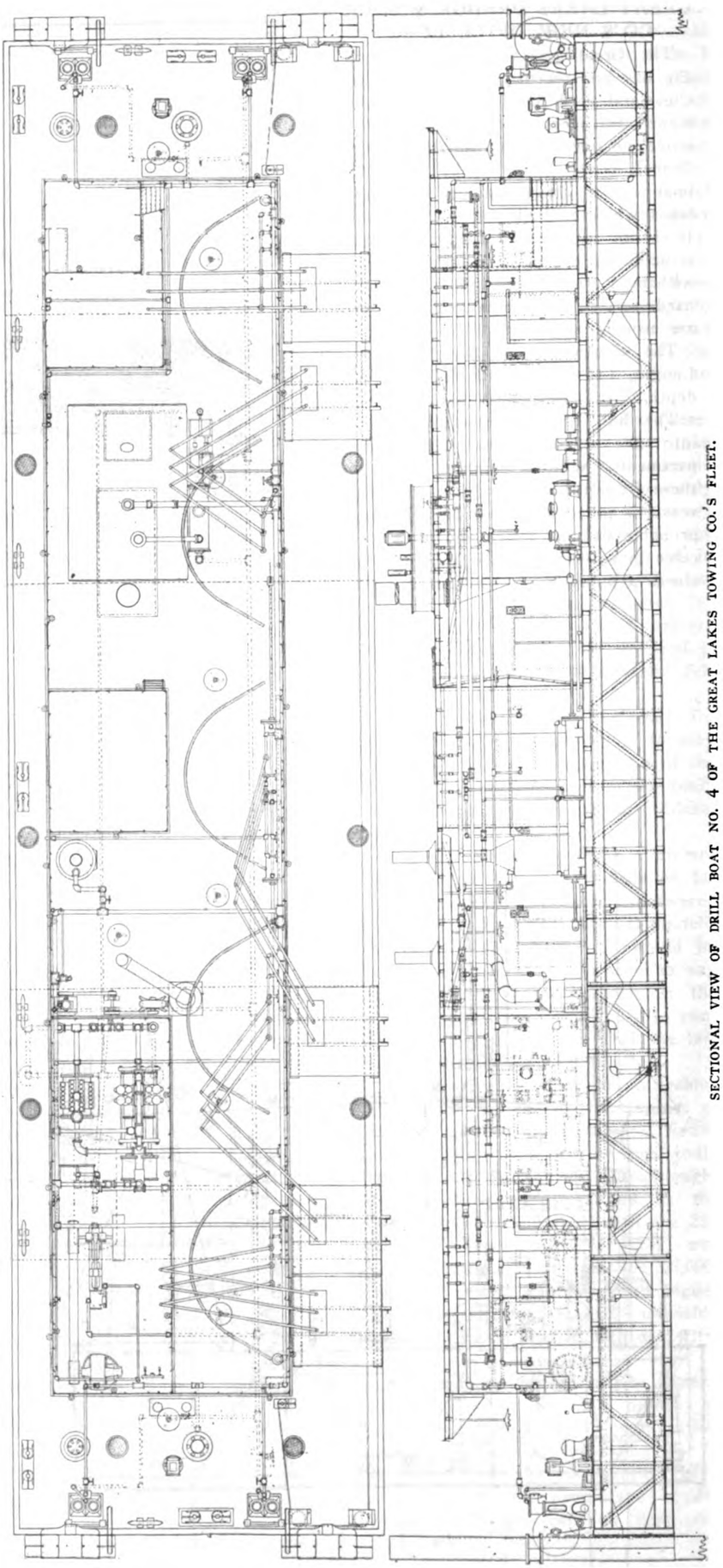
boiler, coal bunker, store room and office and is constructed of steel framing and plating throughout. In the pump room are two hydraulic pumps for operating the drill and traveling cylinder. There are five drill frames arranged along one side which travel longitudinally on a track. The cylinder controlling the vertical motion of the drill stands upon the floor of the drill frames between the angles forming the guide for the drills and is operated by hydraulic power. The drills used are of the latest design of the Ingersoll Rand Drill Co.

Steam is supplied by a boiler of the cylindrical return tube type. It has two Morrison corrugated furnaces. The steam pressure is 125 lbs. per sq. in. The coal bunker has a capacity for about 40 tons of coal.

The boat is lighted throughout by electricity, the equipment being of the most modern type, and installed according to the best marine practice. The dynamo is of 125 K. W. capacity, built by the Westinghouse Electric Co., belt driven from an 8 in. by 12 in. horizontal engine and runs at 1,100 R. P. M. There are over 150 incandescent lamps arranged in clusters, wall brackets and hanging fixtures. The circuits are subdivided into sections, controlled by switches located in fireproof distribution boxes, so that all lights or only such section as is required may be in use at one time. There are a number of plug receptacles distributed about the boat for attachment of portable hand lamps for use whenever they may be required. The wiring is all carried in metal conduits with water-tight junction boxes and all fixtures are waterproof, all outside and wall lamps being fitted with heavy globes and strong wire guards. The electrical plant was installed by the S. K. Elliott Electric Company, of Cleveland.

The boat was launched on June 25, 1908, and was christened by Miss Bernadette Keane. She left Cleveland on July 19, 1908, and was put in operation at Sandusky, O., for several weeks on a contract of the Great Lakes Dredge & Dock Co., at that place, where all her machinery was thoroughly tested out and proved entirely satisfactory. She has now been moved to the Detroit river where she will be in operation for about the next two years on the work for which she was designed.

The boat was designed by and all work carried out under the supervision of Alexander Hynd, of the firm Messrs. Nacey & Hynd, marine architects and consulting engineers, Cleveland, O.



SECTIONAL VIEW OF DRILL BOAT NO. 4 OF THE GREAT LAKES TOWING CO.'S FLEET.

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SUBMARINE JACKET FOR DIVING AND OTHER PURPOSES.

The submarine jacket shown in detail in the accompanying illustrations is intended for use in diving operations or for any contingency where it is desired that a person should remain under water for a length of time. It is particularly designed, however, as a life-saving device to be used on submarine vessels, it being intended that each member of the crew of such a vessel shall have his own jacket and use it in an emergency for making his escape from the vessel to the surface. The submarine jacket is the invention of Lawrence Y. Spear and Frank T. Cable, of Quincy, Mass.

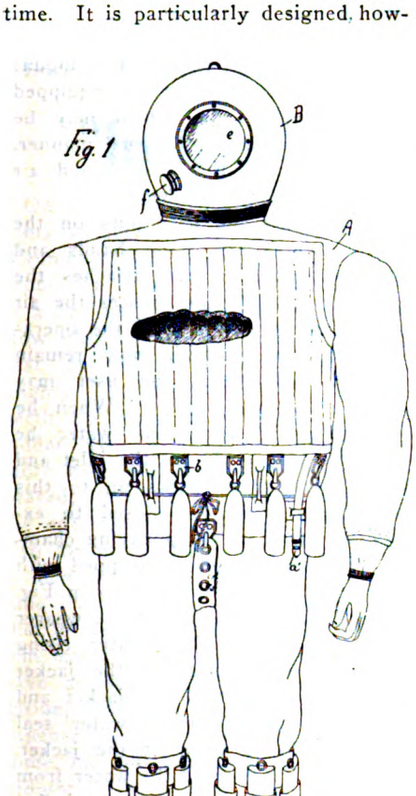
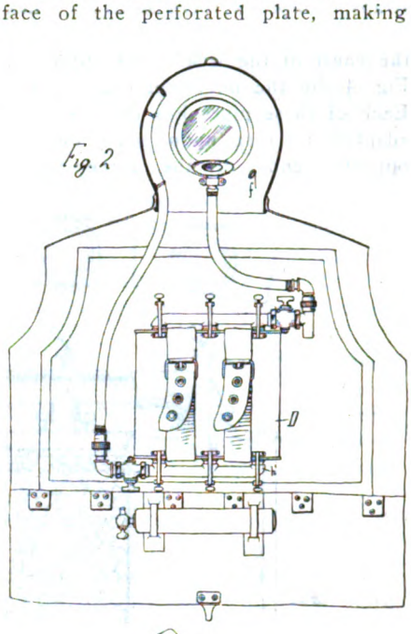
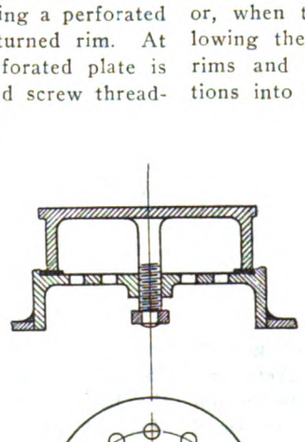
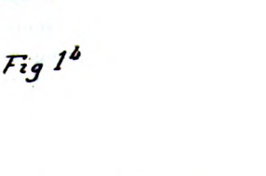


Fig. 1, in the drawings, is a sketch of a man wearing the jacket. Fig. 2 is a section of the jacket looking at the inside of the front and showing the air purifying chamber and associated parts in elevation. Fig. 3 is an elevation partly in section of the air purifying chamber and the associated parts separated from the jacket. Fig. 4 is a top plan view of the air purifying chamber with the inlet pipe removed. Fig. 5 is a detailed sectional view of one of the seats by which the inlet pipe and the leading off pipe are attached to the air purifying chamber. Figs. 1a and 1b are detailed views of a valve mounted in the face of the helmet by which communication may be established with the outside air. Figs. 3a and 3b are plan views of the sheets forming part of the strainer, and Fig. 2a is a perspective of a nose clip.

The jacket comprises a body portion A and a non-collapsible helmet B, the body portion being of canvas or any other material used in the manufacture of diving suits, and having on the front and back air chambers *a* provided with inlet pipes a^1 by which they may be inflated. The jacket also carries a series of hooks to which weights are hung in the ordinary manner, and has a strap passing between the legs of the wearer which can be adjusted to hold the jacket in place. The arms end in rubber wristlets which fit tightly about the wrists of the wearer and are made comparatively air-tight by the use of binding cords. In the face of the helmet, which is secured air-tight to the neck in any appropriate manner, there is a glass plate for the ordinary purposes of observation, and at one side of this plate a valve *f*, shown in details in Figs. 1a and 1b. This valve comprises a cylindrical casing welded to the side of the helmet and having a perforated top plate with an upturned rim. At the center of this perforated plate is a downwardly projected screw threaded boss into which is screwed the stem of a cap. This cap has a rim which engages a gasket on the upper face of the perforated plate, making the valve, when the cap is screwed down, perfectly air and water tight, or, when the cap is screwed up, allowing the air to enter between the rims and pass through the perforations into the helmet.







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The air purifying chamber D, which is secured on the inside of the front portion of the jacket by appropriate straps, comprises three separate tanks held together on a curved line to fit the chest of the wearer—as shown in Fig. 4—by the inlet and outlet pipes. Each of these pipes has three sockets adapted to rest upon seats on the opposite ends of the three tanks, leakage being prevented by gaskets interposed between the sockets and seats, as shown in Fig. 5. On the opposite sides of each tank are small brackets adapted to grasp the hooked ends of the straps secured to the cross piece, the cross piece being provided at its center with a thumb screw which has its end engaging a depression on the upper face of the pipe. The screwing in of the thumb screws tightly clamps the pipes in place, leakage being prevented by means of gaskets.

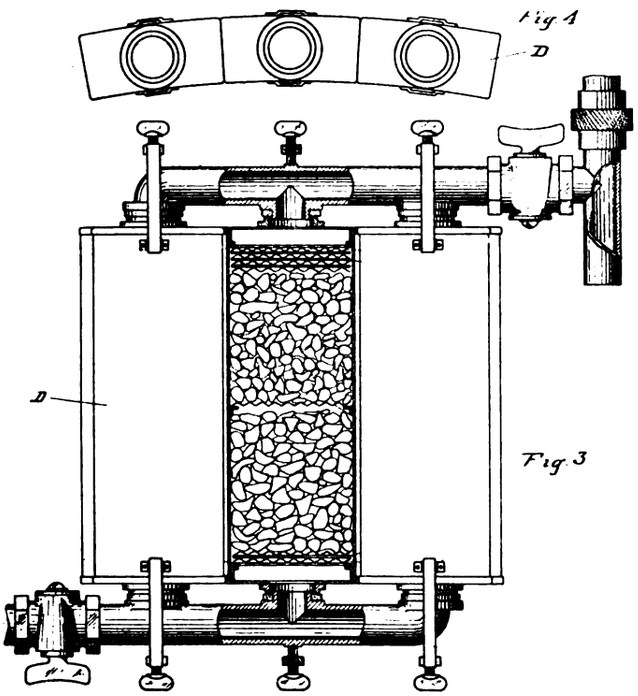

Fig. 4

Fig. 3

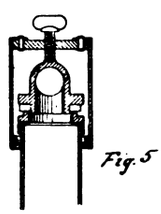

Fig. 5

Each tank is intended to be filled with a material capable of absorbing carbon dioxide, and preferably water also, and liberating oxygen for purifying and revivifying the air. The inventor's preference of material is that known as oxylithe P. S., a compound containing sodium and potassium peroxide and made up of two parts of potassium peroxide to one part of sodium peroxide, to which is added 2 per cent of anhydrous sulphate of copper. This material is in powdered form and is separated from the inlet by a series of sheets which are alternately a sheet of wire gauze and a sheet of perforated asbestos, held in place by a plate spaced from the inlet as indicated in Figs. 3a and 3b. About the center of each tank in the body of the oxylithe is placed a sheet of wire gauze, and at the lower end of the tank and adjacent to the outlet is another series of alternate gauze and asbestos sheets.

At the free end of the inlet pipe is a stop cock of any appropriate construction, and beyond the stop cock the inlet pipe runs into a trap in which any saliva breathed into the instrument may accumulate. A flexible pipe is secured to the upper open end of this trap by a union which may be readily disengaged, the pipe being sufficiently stiff to prevent collapsing under pressure and continued up in the front part of the helmet to a position in front of the mouth of the wearer, where it is provided with a mouth piece. It is intended that the wearer should place this mouth piece inside his mouth and bite his teeth over the body of it, so that he breathes directly into the tube. The outlet pipe is provided with a similar stop cock and union, connected to a flexible pipe continued up well into the upper part of the helmet and opening into the helmet.

Below the air purifying tank, when it is attached, it is preferred to mount a compressed air reservoir equipped with a needle valve which may be opened or closed in the usual manner. The purpose of this compressed air will be further described.

In operation the user puts on the jacket, secures the wrist bands and strap between the legs, attaches the necessary weights and inflates the air bags. During this part of the operation the valve for air may remain open, in order that the user may breathe from the outside. When he is prepared to enter the water he opens the stop cocks on the inlet and outlet pipes, these cocks up to this time having remained closed to exclude the air from the purifying chamber. The mouth piece is gripped with the teeth, the nose clip shown in Fig. 2a is attached in place and the wearer enters the water. The water rising under the lower edge of the jacket compresses air within the jacket and the helmet and forms a water seal above the lower edge of the jacket. If the user has entered the water from a submarine boat, the air in the jacket will be at the same pressure as the air in the boat and will usually sufficiently exclude the water. If, however, it is necessary for any reason to further exclude the water, as when the user moves into a place of high water pressure from a place of low air pressure, air may be admitted from the compressed air reservoir by opening the needle valve aforementioned.

When the user breathes into the mouth piece, the carbon dioxide and the moisture of his breath pass into the purifying chambers, where the carbon dioxide is absorbed by the material and preferably also the water, and oxygen is given off which is inhaled by the user. When the oxylithe P. S., above described, is used, the reaction may be expressed as follows:

$$K_2O_4+Na_2O_2+2CO_2 = K_2CO_3+NaCO_3+2O_2$$

The potassium carbonate thus produced is extremely deliquescent and the sodium carbonate is slightly so; the moisture of the breath will be rapidly absorbed by these materials. Under these conditions all the oxy-

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gen which has been combined with the carbon to produce the carbon dioxide is liberated and the air is thus kept at its original purity. It will be understood that, though the inventors' preference is the particular material herein mentioned, there are other materials which may be used for the purpose, such, for example, as potassium, sodium dioxide, $NaKo_3$.

During the breathing operation the other ends of the purifying tanks are connected with the air within the helmet by the pipe shown in Fig. 2, so that the air pressure is equalized throughout the system and in the lungs of the user. The weights hung from the hooks may be detached to allow the user to rise to the surface, or the jacket may be otherwise manipulated in the ordinary manner of diving suits.

"In the Merchant Service."

On the arrival of the steamer Alroma at her home port, Higgins, the Alroma's third engineer, had found promotion awaiting him. Promotion, in a line like the Blue Moon line, was slow, this being due to the fact that, first, the ships of the line were mighty desirable vessels to have a berth on; second, the higher up the ladder you managed to climb the more desirable the berths ahead appeared; and, third, chief engineers are notoriously long-lived. Promotion also meant "shifting ship," and, when a man has spent some considerable time on one vessel, he somehow finds that he has managed to gather around him more gear than his grip and bag have accommodation for. Accommodation, therefore, is obtained at the expense of a man's shipmates, and at some far off future date, when the promoted individual's ship and his friends' ship are in dock together, the borrowed bags, bearing some additional marks of rough travel and handling, are cheerfully returned.

Higgins was packing up. At least, he thought he was packed up, but a few trifles like tools, rubber boots, books and other odds and ends lying around convinced him that some more packing had to be done. Accommodation was borrowed in the shape of the fourth engineer's grip, and the packing, with Higgins as the committee of ways and means, proceeded merrily.

But it was not to be imagined that the fourth engineer, who was parting with his grip for an indefinite period, could allow the opportunity of getting some little recompense for his kindness to pass, so he drifted into the third's quarters to lend a hand and obtain some information valuable to an engineer in charge of the Alroma's starboard engines. Incidentally it may be remarked that the third and fourth were responsible for the condition of the starboard and port engines, respectively.

A COMMITTEE OF WAYS AND MEANS.

"Still packing?" asked the fourth by way of conversation, as he seated himself on the only available space in the room.

"Huh?" answered his superior officer rising from the floor. He had been persuading the fourth's grip to close by kneeling on it, and the fourth's unexpected entry was at the least embarrassing. The bag, freed from the restraining weight, gaped open and displayed the contents.

"Aw, say," protested the fourth, "don't you know better than to pack dirty gum boots in another fellow's grip?"

"Listen to him," was the answer, addressed to no one in particular, "after me wiping the boots off with a piece of clean waste, too. Don't you think that I know how to keep a grip clean yet?"

"Sure you do," said the fourth, grasping the opportunity of broaching the main subject he particularly wished to discuss with the third, "haven't I good reason to know that you are an expert on cleaning up and all that pertains thereto?"

"What d'ye mean?" asked the expert, suspiciously. He was supposed to be resting from his labors, but in reality was awaiting the departure of the fourth before he resumed the packing of the grip in question.

"Well," said the fourth, "take the starboard engines in comparison with mine. Why, they've got the port side skinned a mile."

Silence on the part of the third, who had his suspicions.

"Look at the casings and lagging plates," continued the fourth, "talk about polished work!"

"Oh, you mean the stove-polish work," exclaimed the third, seemingly just awakening to the fourth's meaning. The matter of stove-polish work had long been a bone of contention between them.

"Sure," said the fourth, smiling ingratiatingly, "don't you think that, as you are shifting ship and I am getting your job, the least you can do is to put me wise?"

"Well," said the departing third, as he leaned against the edge of his bunk and carefully filled his pipe, "I suppose I can lay bare the awful secret. Of course it is up to you to use your judgment in the matter of keeping it to yourself."

"You can place your trust in me, Joe," whispered the fourth, in a voice husky with emotion. "How do you mix the polish?"

"When you first came on the ship," proceeded the third, "I noticed that

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you watched my every move intently and my every action interested you intensely. No interruptions, please. Whatever improvement or alteration was made on the starboard engines was faithfully reproduced on the port engines. Should I take it in my head to have a certain eye-bolt filed and polished, the selfsame eye-bolt was polished on the other engine. A little vermilion paint on the journals of my side meant a corresponding brightening of the machinery on yours."

"Aw, get it set to music," said the disgusted fourth, "blamed if you ain't the limit when you are wound up."

"The clatter of the scaling hammers in the bilges on my side," continued the third, unheedingly, "formed a duet with the clatter of yours. In fact, this went on till you fell down in the polish. There I had you beaten."

"The plot thickens," muttered the fourth.

"Lord," laughed the third, "when I think of the way you and your bunch of wasters prowled around to find the composition of our polish I just have to smile. Should I go in the store to prepare it, I was rubbered at through the gratings. Everywhere it was the same, eagle eyes always on the alert. Then you started to experiment. Your first attempt, I think, was a composition of black lead and cold tea. Your next, if I remember rightly, was a peculiar-smelling mass containing vinegar. Then you tried—"

"You seem to be pretty well posted," broke in the angry fourth.

"Curb your wrath," said his superior officer, "that is, if you really want the information."

"Aw, go ahead," said the resigned fourth.

"Well, you and your men commenced to lose flesh worrying about our secret preparation. Your experiments had each a worse result than its predecessor. All the scouting and detective work was without avail. They tell me that you even tried stale beer and black lead."

"Ha, ha," laughed the fourth weakly; "but, don't you think I've listened to enough of this talk of yours. Come on—what's the answer?"

"The answer," said the third, bending forward to meet the eager listening ear of the fourth, "is water!"

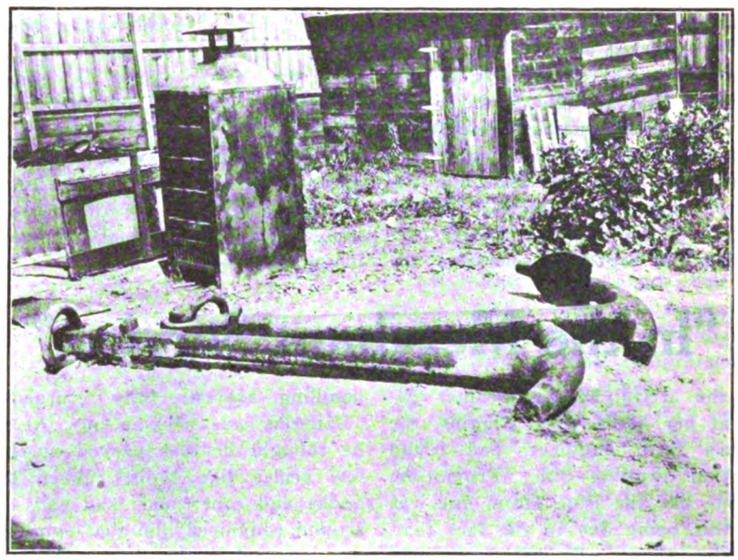
"What?" said the astonished fourth.

"Water, just water," answered the third. "Neither vinegar, tea, beer or any other fluid was in the polish except water."

"We tried water, but it wasn't much account," said the fourth protestingly.

"Yes, you maybe did," answered the third, "but your men and their engineer were so confident that the other side had some special method of preparing their polish that it was only a half-hearted attempt. My advice to you, Jimmie, as an older man and one with a little more experience than you, is: 'Don't encourage laziness in any form.' If your men had used a little more elbow grease and devoted less time to trying to unearth the other side's secret, your side would have looked every bit as good as mine. And you, as their engineer, filled them with misplaced energy. Now, chase yourself. I've got to finish this darned packing."

THE "STAND-BY" MAN.

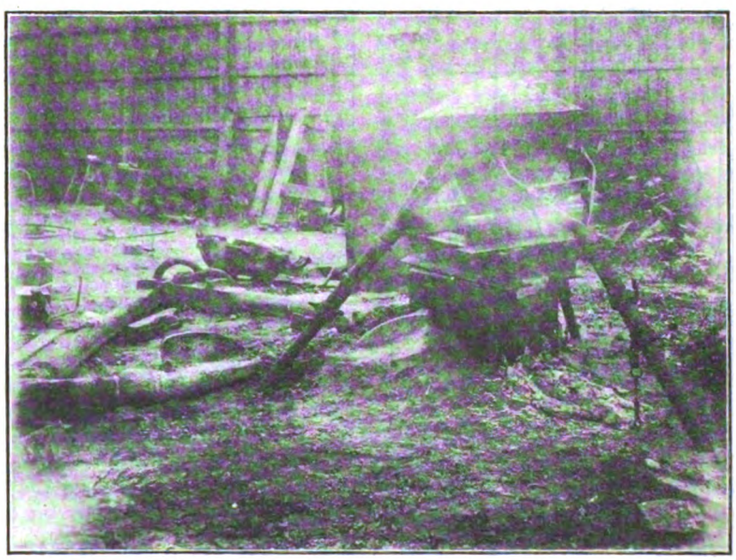


ANCHORS PREVIOUS TO WELDING.

INTERESTING ANCHOR REPAIR.

The accompanying photographs illustrate an interesting anchor repair recently carried out at the works of the Goldschmidt Thermit Co., Jersey City, for the Gilbert Transportation Co., of Mystic, Conn. The repair comprised the welding of three flukes to two anchor forgings. Fig. 1 shows the anchors previous to welding, Fig. 2 the mold box and crucible in position just after the pouring of the thermit steel, and Fig. 3 the three welds complete. Owing to the fact that the flukes which formerly belonged to the anchor were lost, it was necessary to make special castings for them, which were afterwards welded to the main part of the anchor.

In making the welds, a space of



SHOWING MOLD BOX AND CRUCIBLE IN POSITION.

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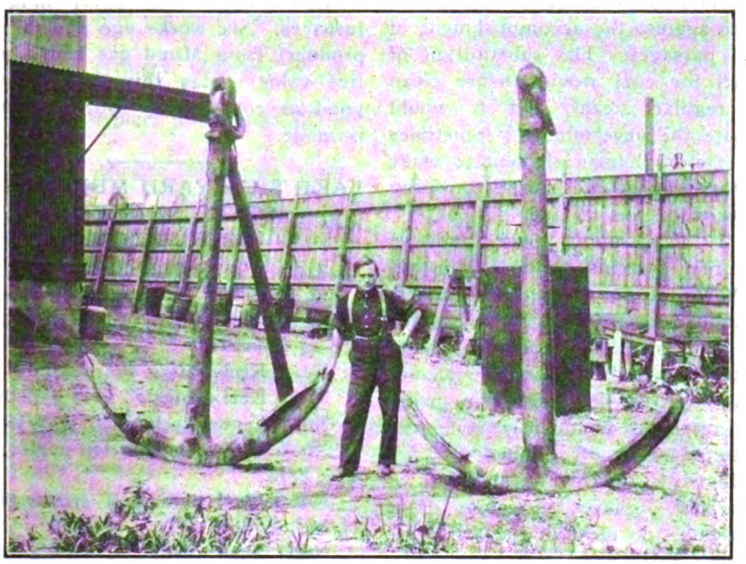
1½ in. was left between the flukes and the main forgings, and a wax collar formed about this opening of the exact shape which it was desired to have the thermit steel collar or reinforcement assume. A mold box was then placed in position and filled with a mixture of one-third fire clay, one-third ground fire brick and one-third sand. This was tamped about the wax matrix, openings being left for a narrow gate, large riser, and a small hole at the bottom of the mold. The next operation was to direct the flame of a powerful compressed air-gasoline torch into the lower opening, thus melting out the wax and bringing the parts to be welded to a bright red heat. As soon as this had been accomplished the lower opening was plugged up with dry sand core, backed up by a few shovelfuls of sand.



SHOWING COMPLETED WELDS.

In the meantime a crucible containing 90 lbs. of thermit, 16 lbs. of mild steel punchings and 1¼ lbs. of pure manganese was placed in position over the pouring gate of the mold, and the thermit ignited as soon as the lower opening had been closed up. At the completion of the chemical reaction the thermit steel was tapped into the mold, where it occupied the space formerly filled by the wax. This operation was repeated for each of the welds, and the entire repair was a success in every sense of the word.

The Goldschmidt Thermit Co. is now doing repair work on a very extensive scale at its Jersey City works, and is making a specialty of welding crank shafts, electric motor cases, gear wheels and other broken wrought iron and steel sections.

WHY OIL FUEL WAS NOT ADOPTED.

In an article in the *Times* Engineering Supplement, on the "Six Performances of the New Cunarders," Sir Wm. H. White, who was consulting naval architect for the Mauretania, says:

Economical as the steam turbines have been proved to be in the new Cunard steamships, the enormous power required to drive them at the high speed desired involves great coal expenditure. Mr. Bell gives 5,400 tons as the total weight of coal burned on the voyage in question from Liverpool to New York, and 1,090 tons had to be transferred from bunkers to boiler-furnaces every 24 hours when running at 24.65 knots. All possible means for minimizing labor in coal trimming and stoking were embodied in the design of these vessels, but the task remains a heavy one, and the efficient working of the boilers and economical combustion of the coal necessitates most careful organization and supervision. When it is considered that the power developed exceeds by more than 50 per cent that of the largest and swiftest Atlantic steamers previously built, and that the 25 boilers occupy a length of about 350 ft., being placed in four separate compartments, it will be understood that the task is no easy one, and calls for special qualities and experience on the part of those charged with its supervision. Here is a case where oil fuel would have been of the greatest value had regular and adequate supplies been available at prices which could be accepted by the Cunard Co. This matter was thoroughly considered in the stage of design. It was recognized that there would be a considerable gain in weight and space required for fuel, large economies of labor in the stokehold and the numbers in its staff, easier regulation of the steam, and more uniform production, as well as considerable advantages in shipping fresh supplies of fuel in port. Guarantees of regular supplies at acceptable prices could not be obtained, however, and the use of coal was decided upon; but it would be an easy matter to adopt oil-fuel at any time either wholly or as an auxiliary to coal, if the conditions favored that course.

Sir William bears testimony to the steadiness of the great ships, and to the absence of excessive vibration, and says: They make light of weather that would be seriously felt by most of their predecessors, and it is a singular experience to sit in one of the public rooms on the uppermost deck, high above water, and to look out on a raging Atlantic sea, through which the steamship is plowing her way rapidly and steadily. It is only when an ordinary vessel is met or overtaken that the real character of the sea becomes apparent, and the passenger in the larger vessel realizes fully the advantages obtained by increase in size.

OIL FUEL VERSUS COAL.

In the Liverpool *Journal of Commerce,* discussing Sir William White's article in the *Times,* Mr. J. J. Kermode says:

Sir:—If the Cunarder Lusitania should be fitted to burn oil fuel, a comparison of what could be accomplished may be stated as follows:

1. 4,000 tons of oil fuel could be stored in the double bottom, thus leaving the coal bunkers available for cargo.

2. 3,300 tons of oil fuel will serve for the voyage from Liverpool to New York when traveling at a rate of not less than 25 knots per hour.

3. The rate at which steam would be made would be uniform throughout the voyage, and this would reduce the time taken to accomplish the voyage by at least eight hours.

4. The condition of the boilers would be normal throughout the voyage, as there would be neither soot nor ashes, there would be no loss of power owing to the fact that there would be no fires to clean, and for the purpose of making up time the boilers could be forced beyond what could be accomplished by coal by an

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amount not less than 25 per cent more than the best performance attainable with coal, and there need be no smoke, as perfect combustion is easily obtained. The operation of cleaning fires (when coal is used) involves a loss of quite 10,000 H. P. every four hours.

5. Of the 312 firemen and coal trimmers now employed, 285 might be dispensed with, and more agreeable occupation found for them under healthier conditions of life as longshoremen handling the extra cargo which would be carried; 27 intelligent men of the greaser class would serve to attend to the oil jets with better results than are now obtainable with coal.

6. The oil fuel would cost (today) from $7.50 to $8 per ton, f. o. b. at New York, and if we take the higher figure as the price, the cost of 3,300 tons of oil fuel would be $5,280.

7. The wages of 285 men at 25s per week would be saved.

8. Two hundred third-class passengers could be accommodated in the space occupied at present by the 285 firemen, a further gain to the steamship company.

10. Six thousand tons of coal are carried in the bunkers for the voyage from Liverpool to New York, and about 5,500 tons of coal are consumed to maintain a speed of 25 knots per hour. If the coal bunkers should be used for cargo (in the event of oil fuel being substituted for coal) at a rate of £1 per ton for each ton carried, this would represent a considerable gain to the steamship owners.

11. The ships might take in a full supply of oil fuel in three hours, silently and cleanly, whereas it takes 20 hours to fill her bunkers with coal. Need I say that these 20 hours are associated with grime and bad language. In the event of the ship being used as a cruiser, high speed, regular steering, smokeless combustion of fuel, and expeditious bunkering are all-important factors to be taken into account. If oil fuel should be adopted, it is as easy to bunker at sea as in port, and this is a matter of the gravest importance in time of war.

12. 5,500 tons of coal at 18s 6d per ton f. o. b. Liverpool or New York, will cost £5,087, and this displaces cargo (not necessarily the same weight) at £1 per ton.

13. Should the Lusitania's bunkers be required for coal for the westward passage, and assuming that she only carries 500 tons of cargo when proceding west, it is quite clear that oil fuel might enable her to make the eastward voyage when her empty coal bunkers would be available for cargo.

14. Certain structural modifications in the coal bunkers might be necessary in the event of these being used for cargo, but no modification of the boilers would be necessary to enable either coal or oil fuel to be used at will, and as occasion demanded.

15. The practical impossibility to get stokers to work in so united a fashion that each of the 25 boilers will register the same steam pressure at all times, coupled with the fact that a number of the numerous fires have to be cleaned each watch, makes it difficult to ensure an even rate of speed, and both these circumstances operate against the accomplishment of record passages. The substitution of oil fuel for coal would ensure clean fires, regular steam, and it would eliminate the uncertain and sometimes unsatisfactory human element to make way for regular and automatic firing by means of the oil fuel system.

16. My firm supply three kinds of liquid fuel systems, to meet the requirements of naval ships, of numerous industrial process furnaces, for steam boilers of every kind, both land and marine, and the importance of making use of liquid fuel in many special cases is abundantly evidenced by the adoption of oil fuel for fire brigade work and for naval ships.

Liverpool, London, and many other fire brigades do most of the fire fighting by its aid, using the Kermode system, and among the advantages may be mentioned rapidity in the raising of steam, a steady maintainance of a steady and regular flow of water from the hose director, clean, smokeless, no sparks, no soot deposit, automatic stoking, economy in manning engine, and the greater amount of fuel which can be carried on the engine; the absolute control over the fire, which can be raised, lowered, or stopped in an instant, must be of first importance to fire brigade men.

The failure of a feed pump or injector, or the breaking of a gauge glass might result in a calamity where coal is used as fuel unless the fire were instantly dropped, but where oil is used the fire is under instant control by shutting off the oil.

If it should be necessary to drop a coal fire for any reason some time must elapse before the engine is ready to pump her full duty again, whereas if oil is used the fire is extinguished instantly, and as quickly restarted.

Oil fuel is not confined to crude petroleum, as is commonly supposed, and we make use of many by-products with perfect success. The latest addition to the number is the by-product (tar) from Mond gas.

The foregoing statement will enable anyone to see that at the present price for crude petroleum in bulk at New York the advantage is with oil fuel. Yours, etc.,

J. J. KERMODE,

M. I. Mech. E., M. S. A., F. R. Met. Soc.

Imperial-chambers, 62, Dale-street, Liverpool.

P. S.—There must be a vast amount of waste material of the nature of grease, oil, or tar, which could all be utilized as liquid fuel for industrial furnaces. Six weeks ago the tar (by-product) from Mond gas had a negative value; today this material is as good as coal in any works where it is made.

LAKE SHIP YARD METHODS OF STEEL SHIP CONSTRUCTION.

BY ROBERT CURR.

Fig. 38 shows the material making up the longitudinal parts of this vessel, and are as follows:

No. 1 Keel plating 40″ x 15/16.″

No. 3 Keel angles 5″ x 4″ x 12/16.″

No. 4 Center keelson 60″ x 9/16.″

No. 5 Center keelson top angles 4″ x 4″ x 8/16.″

No. 6 Shell plating B strake 84″ x 11/16.″

No. 7 Shell plating C strake 84″ x 10/16.″

No. 8 Shell plating D strake 84″ x 10/16.″

No. 9 Shell plating E strake 76″ x 12/16.″

No. 10 Shell plating G strake 78″ x 12/16.″

No. 11 Shell plating H strake 70″ x 10/16.″

No. 12 Shell plating J strake 72″ x 10/16.″

No. 13 Shell plating K strake 69″ x 11/16.″

No. 14 Shell plating L strake 62″ x 15/16.″

No. 15 Shell plating seam strap 24″ x 1.″

No. 16 Shell plating M strake 53″ x 15/16.″

No. 23 Bottom girders A strake 43″ x 6/16.″

No. 23 Bottom girders B strake 42″ x 6/16.″

No. 23 Bottom girders C strake 40″ x 6/16.″

No. 23 Bottom girders D strake 42″ x 6/16.″

No. 24 Bottom intercostals 22″ x 6/16.″

No. 25 Bottom girder angles 3″ x 3″ x 6/16.″

No. 28 Bottom girder top angles 3″ x 3″ x 6/16.″

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No. 29 Tank top plating A strake 36″ x 8/16.″

No. 30 Tank top plating B strake 70″ x 8/16.″

No. 31 Tank top plating C strake 72″ x 8/16.″

No. 32 Tank top plating D strake 70″ x 8/16.″

No. 33 Tank side plating E strake 84″ x 7/16.″

No. 34 Tank side plating F strake 86″ x 6/16.″

No. 35 Tank side plating G strake 45″ x 6/16.″

No. 42 Tank side top 66″ x 9/16.″

No. 43 Tank side top inner angle 5″ x 5″ x 8/16.″

No. 44 Tank side top outer angle 3½″ x 3½″ x 7/16.″

No. 45 Side stringer channel 15″ x 7/16.″

No. 46 Side stringer intercostals 22″ x 6/16.″

No. 47 Side stringer continuous angle 5″ x 4″ x 7/16.″

No. 50 Spar deck channel intercostals 12″ x 7/16.″

No. 51 Spar deck hatch fore and after 12″ x 7/16.″

No. 52 Spar deck channel girders 15″ x 7/16.″

No. 53 Spar deck outer stringer plate 60″ x 1″

No. 54 Spar deck stringer angle 6″ x 6″ x 7/8.″

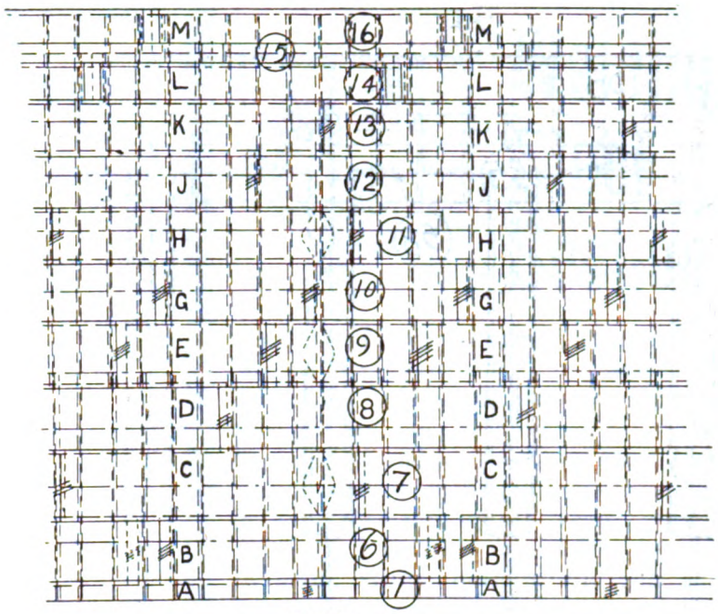

FIG. 39.

No. 55 Spar deck inner stringer plate 60″ x 1.″

No. 56 Spar deck stringer seam strap 24″ x 1.″

No. 58 Spar deck hatch coaming.

All the pieces have been considered in previous articles except the tank and shell plating which may be better explained treating them as a whole or shell plating and tank in one piece.

The shift of butts is of considerable importance both in the shell plating and tank top.

The plating in both cases requires to be watertight so that butts must have a spacing of rivets to accomplish this end.

Fig. 39 shows expansion of shell plating with a good shift of butts—none of them coming closer than 4 ft., and more than one strake between butts coming in same space. Fig. 40 shows the tank top plating, bottom girders, center keelson and tank side plating.

The tank top plating A strake, and the center keelson No. 4, must be considered so that the butts of same do not come closer together than 4 ft.

The same must be considered on B strake, No. 30, and the first bottom girder A No. 23.

C. D, and E strakes, Nos. 31, 32 and 33 on the tank top must be treated likewise and have the same shift of butts 4 ft. away from each other and the girders they fit on.

The tank side plating F and G, Nos. 34 and 35, must have a shift of butts of 4 ft. also, clear of each other, and the top plating No. 42.

Fig. 41 shows the deck stringer arrangement of butts; the outer stringer No. 53 must have at least a shift of 4 ft. away from the sheer strake butts No. 16, and the inner stringer No. 55 2 ft. away from sheer strake No. 16, and 4 ft. from the outer stringer butts No. 53.

The butts of the seam strap No. 56, have a shift of 4 ft. also, clear of the outer and inner stringers.

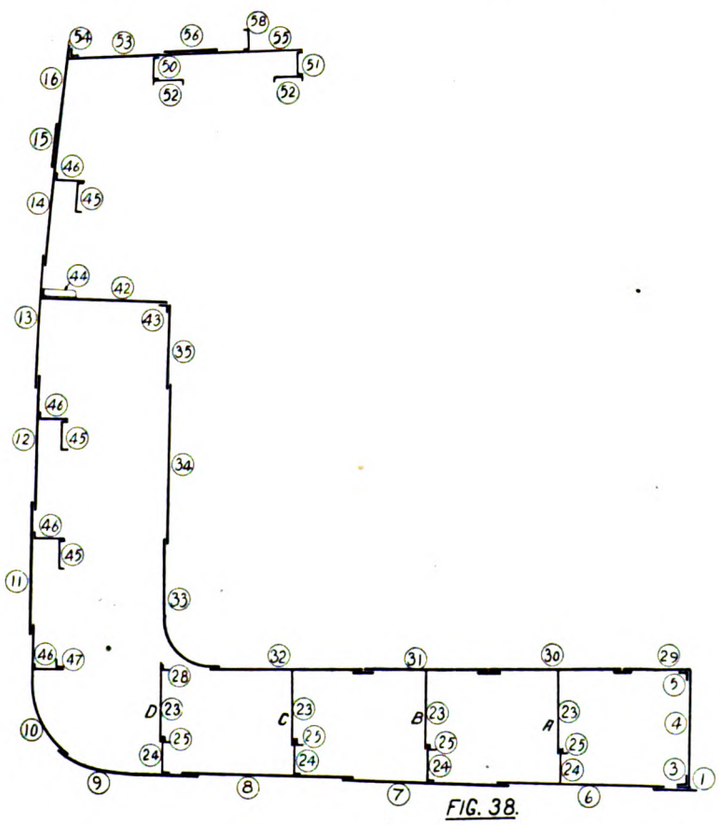

FIG. 38.

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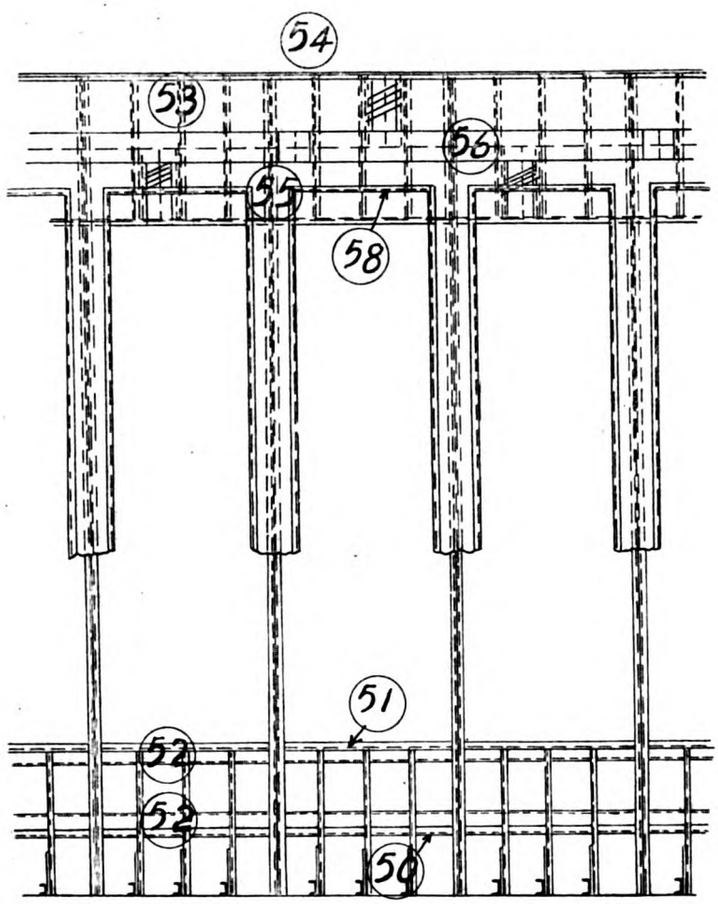

FIG. 40.

The stringer angle No. 54 must be butted no less than 4 ft. clear of sheer strake No. 16, and outer stringer plates No. 53.

The channels No. 50 are intercostal between the beams and No. 51 intercostal between the arch beams.

Spar deck channel girders No. 52 are continuous and must have a shift of butts not less than 4 ft. away from stringer plates over same.

The side stringers No. 45, are continuous and must have a shift of butts with the shell plate strake they come on, of at least 4 ft.

The tank top at side butts No. 42, must be clear of the shell plating strake K, No. 13, 4 ft. and 2 ft. away from strake L No. 14.

The center keelson No. 4, top angles No. 5, keel angles No. 3, and keel No. 1, must have a shift of butts of 4 ft. clear of each other.

Shell plating B, No. 6, must be 4 ft. clear of the girder A No. 23, C shell plate No. 7, 4 ft. clear of B girder No. 23, D shell plating No. 8, 4 ft. clear of girder C No. 23, and E strake No. 9, 4 ft. clear of bottom girder D No. 23.

The bottom girder angles No. 25, must have a shift of butts 4 ft. clear of the plates they are fastened to, and the shell plates on the same line.

The top girder angle No. 28, must be butted 4 ft. away from the girder plate butts on which it is fitted.

In any case butts of plating must not be closer together than 4 ft. throughout the ship.

With the 3 ft. frame space in this construction and the long plate, which can be secured, it is easy to have a two frame space shift of butts equal to 6 ft.

MORISON SUSPENSION FURNACES FOR INTERNAL FURNACE BOILERS.

Designers and builders of boilers, as well as engineers generally, will be interested in the seventh edition of a book entitled, "Morison Suspension Furnaces for Internal Furnace Boilers," just issued by The Continental Iron Works, Borough of Brooklyn, New York City.

The book deals with the use of the Morison suspension furnaces, of which the Continental Iron Works is the sole manufacturer in the United States, in connection with land boilers only, in contradistinction to the application of Morison suspension furnaces for marine purposes. It is a finely compiled and printed volume of nearly seventy pages, bound in a serviceable cover.

There is a fund of valuable data, with numerous illustrations, including a number of important installations of internal furnace boilers using Morison suspen-

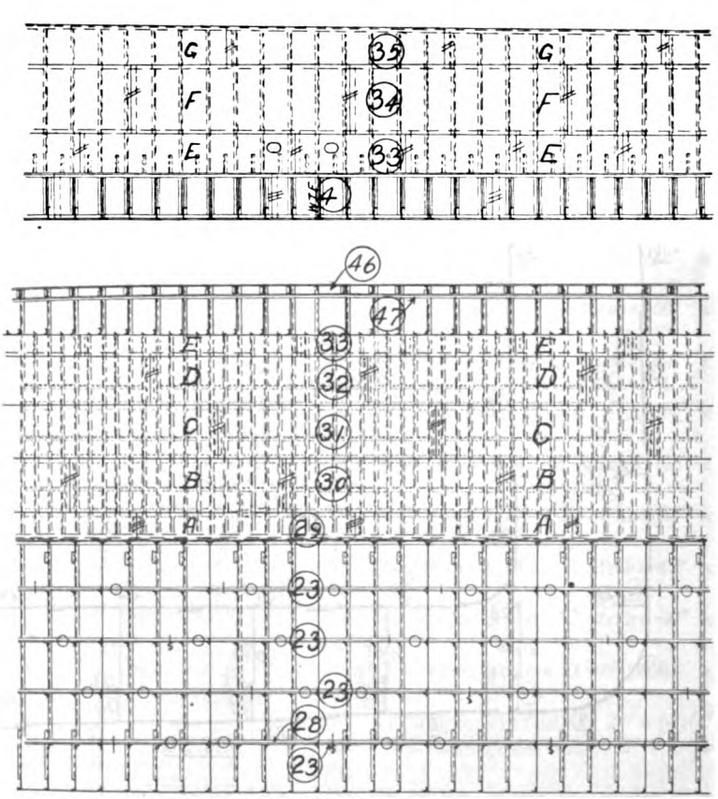

FIG. 41

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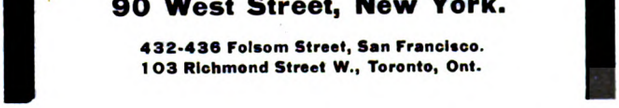

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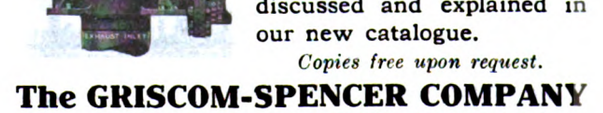

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sion furnaces, together with details of design and construction, tables of pressure and thickness, and rules for calculating same.

The designs shown are for land boilers ranging from 50 H. P. to 300 H. P., and are intended to meet general requirements, it being explained that where boilers are designed to work under other than normal conditions, the designs are offered by way of suggestion only.

A form of specification for internal furnace tubular boilers, which accompanies the design, should prove an important aid.

In the latter part of the book is a partial list of instalations of internal furnace boilers fitted with Morison suspension furnaces, many of which are repeat orders, demonstrating the satisfaction this type of steam generator gives.

This is followed by illustrations and full information regarding the Morison patent furnace fronts and doors for economical and rapid firing, and which are also made only by the Continental Iron Works.

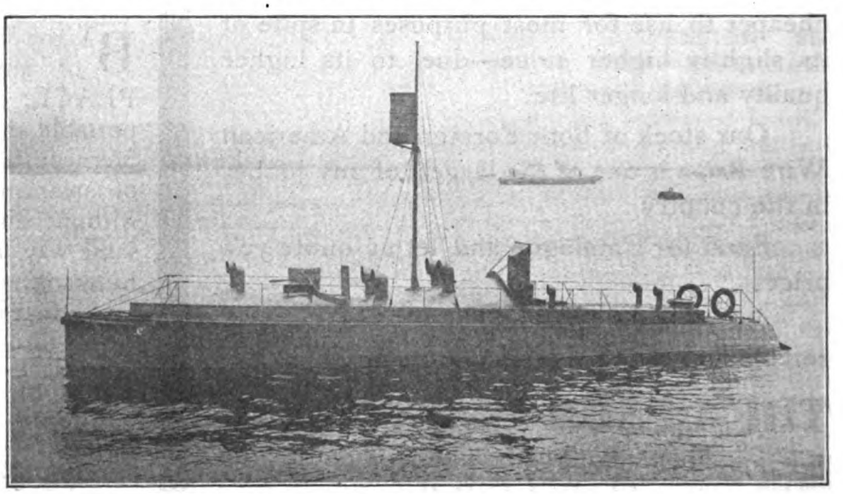
Engineers, architects and boiler manufacturers, will find this book of great assistance to them in the design and lay out of steam power plants.

The book is printed by H. Edwards Rowland, New York City, and a feature of the text is a clever adaptation of photographs, showing various applications of the Morison furnace.

All bids received by the chief of the bureau of yards and docks, navy department, Washington, on Aug. 1, for the construction of a marine railway at the naval station at Key West, Fla., have been rejected, owing to the fact that none was within the amount available.

HIGH-SPEED SHALLOW-DRAFT GUN BOATS.

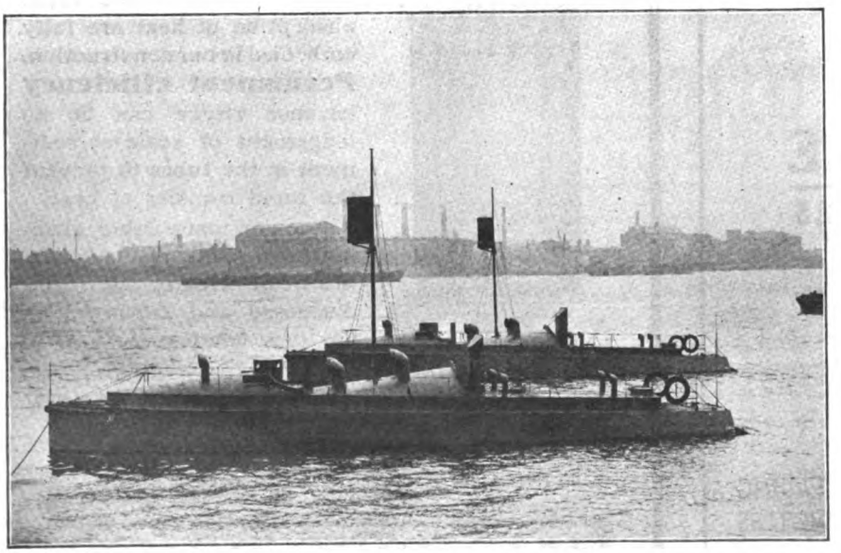
Messrs. Yarrow & Co., shipbuilders, Poplar, London, have just built for the Austro-Hungarian government, two high-speed shallow-draft gun boats which are intended for special river service on the Danube. Their dimensions are 60 ft. in length by 9 ft. beam, and in them special arrangements have been made to prevent the vibration common to some of these fast lightly-constructed vessels.



HIGH-SPEED SHALLOW DRAUGHT GUNBOATS FOR AUSTRIAN-HUNGARIAN GOVERNMENT.

In this respect the builders have been remarkably successful. The hulls are of steel, galvanized, and all the vulnerable parts are protected by chrome-steel protection plating, proof against the Lee-Metford rifle point-blank at short range. The protection plating covers the entire machinery space, the revolving gun tower, the conning tower forward, and the petrol-tank at the stern. The petrol tank apparently forms part of the hull, but in reality it is quite a separate structure from the hull proper; so that in the event of this tank being damaged by shot or otherwise, it is impossible for any of the petrol to find its way into the vessel.

The propelling machinery consists of five 70-brake-horsepower Yarrow-Napier four-cylinder petrol-motors, arranged to drive three shafts. The two wing shafts are each driven by two sets of engines placed in tandem, having four-cylinders to each set—that is, eight cylinders for each wing shaft, while the central shaft is driven by a single set of four cylinders. The dimensions of the cylinders are 6½ in. in diameter, with a 6 in. stroke. The reversing gear is in connection with a central single engine only. A special arrangement for inducing the circulation of air through the engine room is provided by means of a centrifugal fan, so as to avoid the possibility of any accumulation of explosive gases. There is a mast and crows-nest fitted amidships, so as to secure a good range of vision over the high banks of the river, and a revolving gun tower will be placed aft, on which will be mounted a small gun. This gun tower is to be fitted in Austria by the authorities there. Steering stations are provided in duplicate, one forward in the conning-tower and one amidships. The official trials of these two little vessels took place on the River Thames over the Admiralty measured mile, and consisted of a continuous run of one hour, carrying a load of 3 tons, and the mean speed of the two vessels was found to be 22¼ knots. A subsequent trial took place of one hour's duration to test the radius of action, and it was found that at 11 knots, the radius of action was 500 nautical miles, at least three times as much as it would have been had the vessel been propelled by steam. A special condition in connection with these vessels was the limit of draught, which, to the bottom of the screw, was 2 ft. 8 in.



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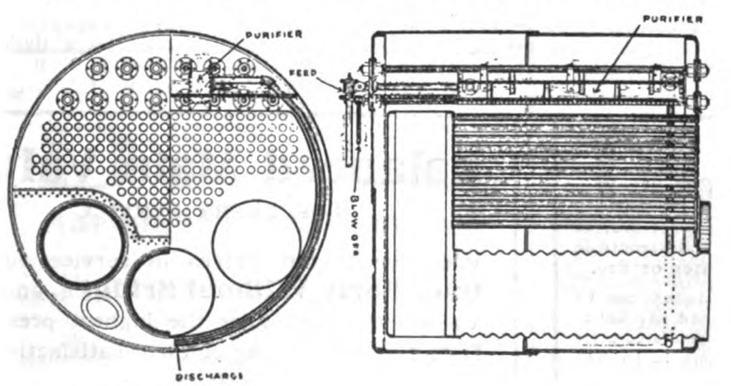

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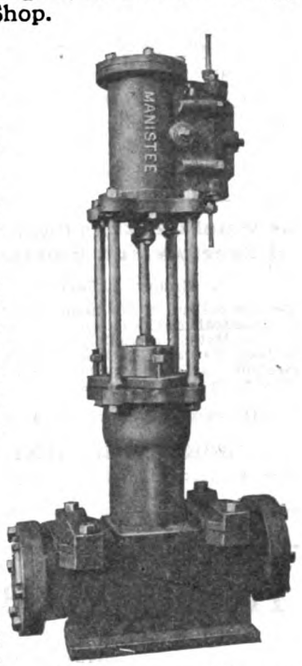

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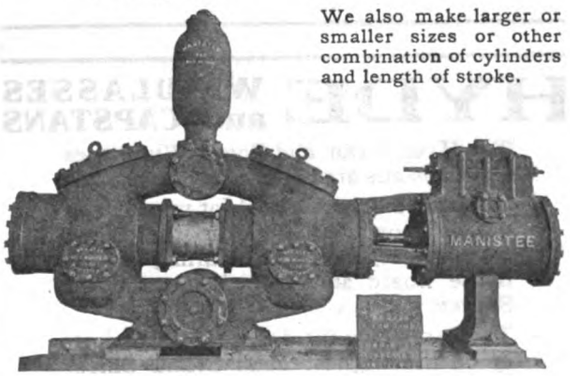
10″ x 6 ″ x 12″
12″ x 7¼″ x 12″
14″ x 8″ x 12″
16″ x 10″ x 18″
18″ x 12″ x 24″
20″ x 14″ x 24″
24″ x 16″ x 24″
30″ x 18″ x 24″

We also make larger or smaller sizes or other combination of cylinders and length of stroke.



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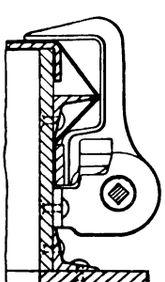

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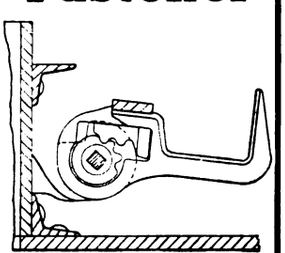

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